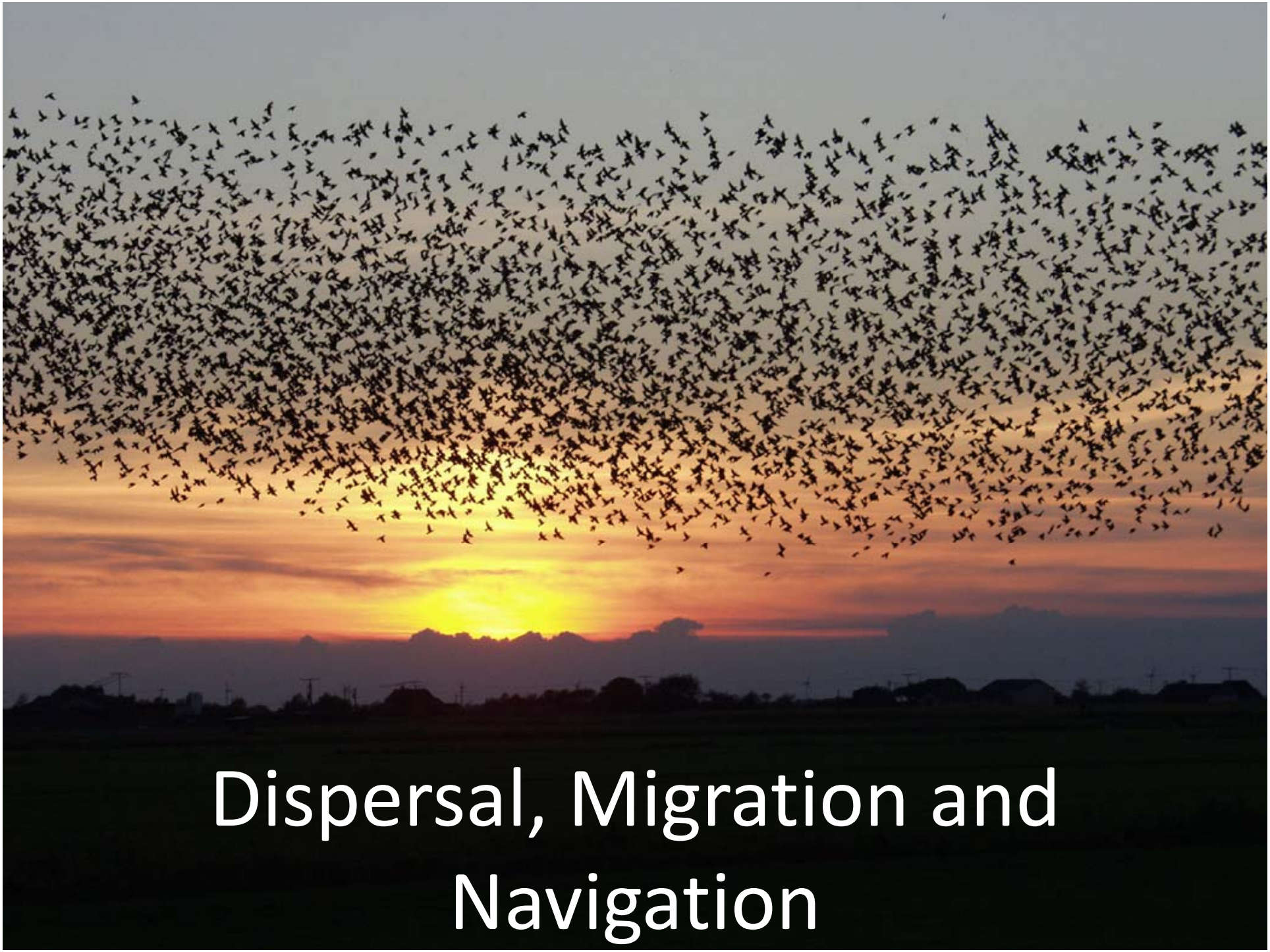


# Dispersal, Migration and Navigation

# What is animal dispersal?

Animal movement away from an existing population/ location.

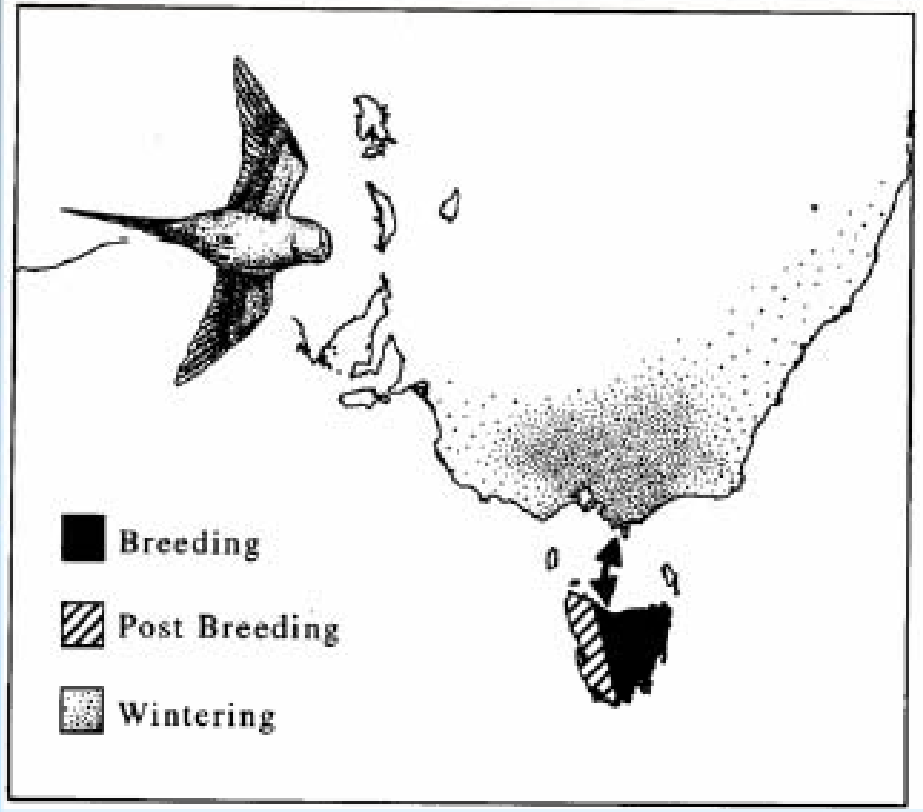
**DISPERSAL:**

1. Natal dispersal = permanent movement an individual makes from its birth site to the place where it reproduces.

2. Breeding dispersal = movement of adults between breeding attempts

# *Swift Parrot*

*Dabb/COG*




Migration: The Biology…/*Oxford U.P.*

# Why animal disperse?

**Ultimate factors responsible for dispersal:**

1) Inbreeding avoidance
2) Competition for mates
3) Competition for resources (e.g., breeding territories)

## Sex-biased dispersal

Among birds, the predominant dispersing sex is female.

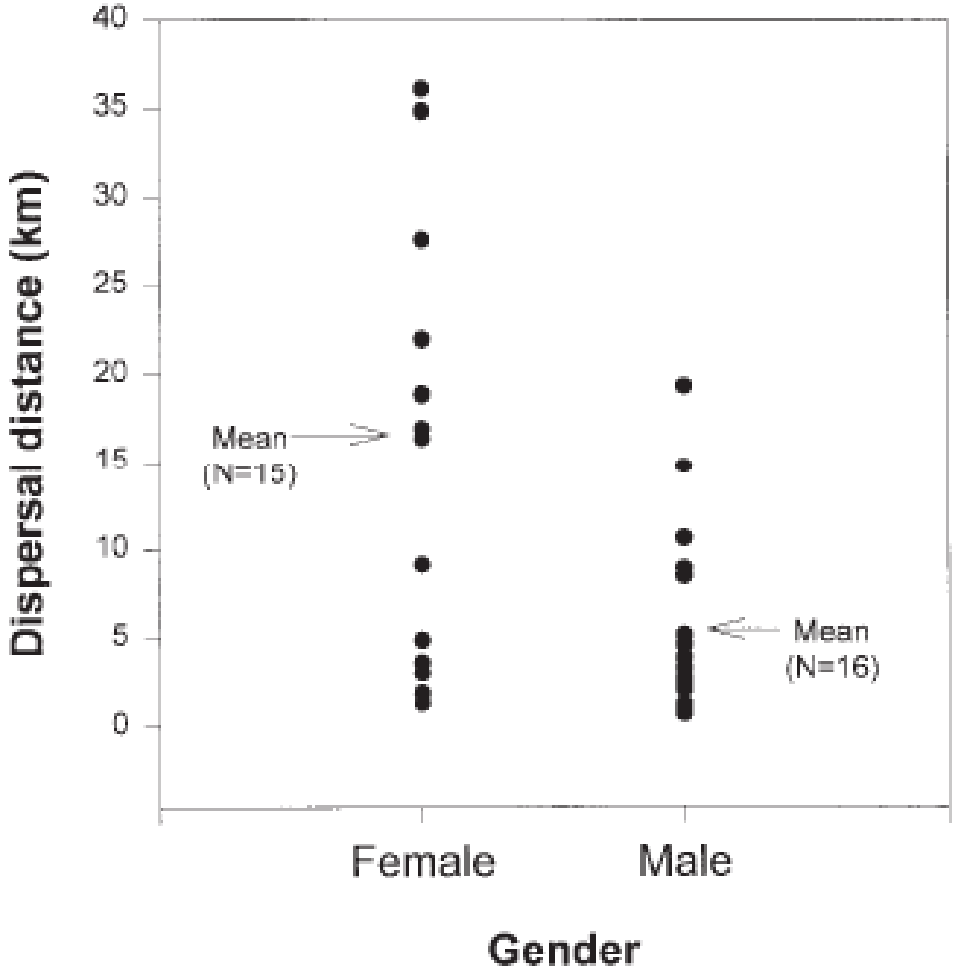



Figure 1.—*Dispersal distances from the natal area to apparent overwintering sites of female (N = 15) and male (N = 16) Western Screech-owls in southwestern Idaho in 1994 and 1995.*

# Sex-biased dispersal

Among birds, the predominant dispersing sex is female.

Among mammals, the predominant dispersing sex is male.

Why?

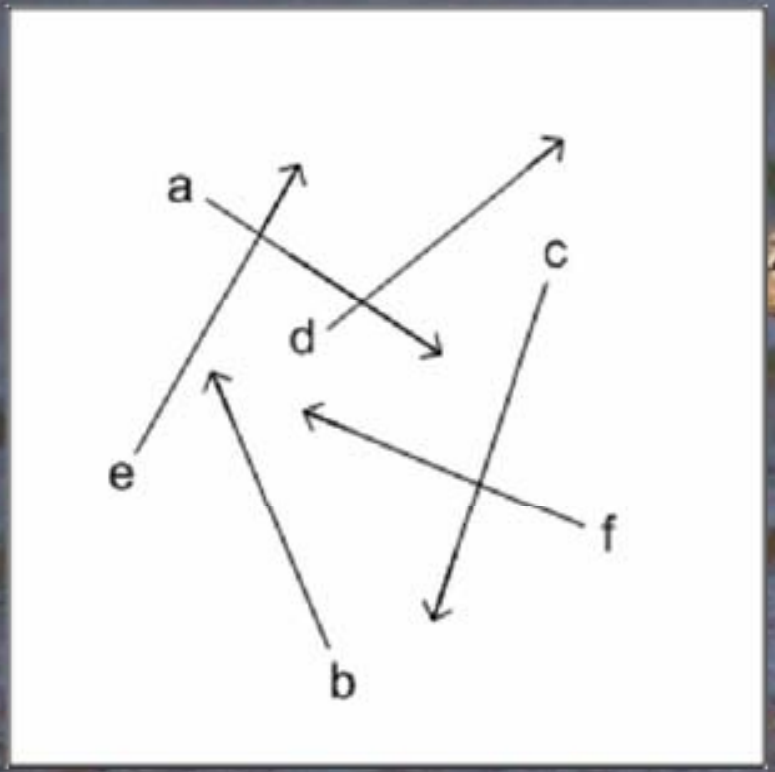
Ground squirrels

# What is animal migration ?

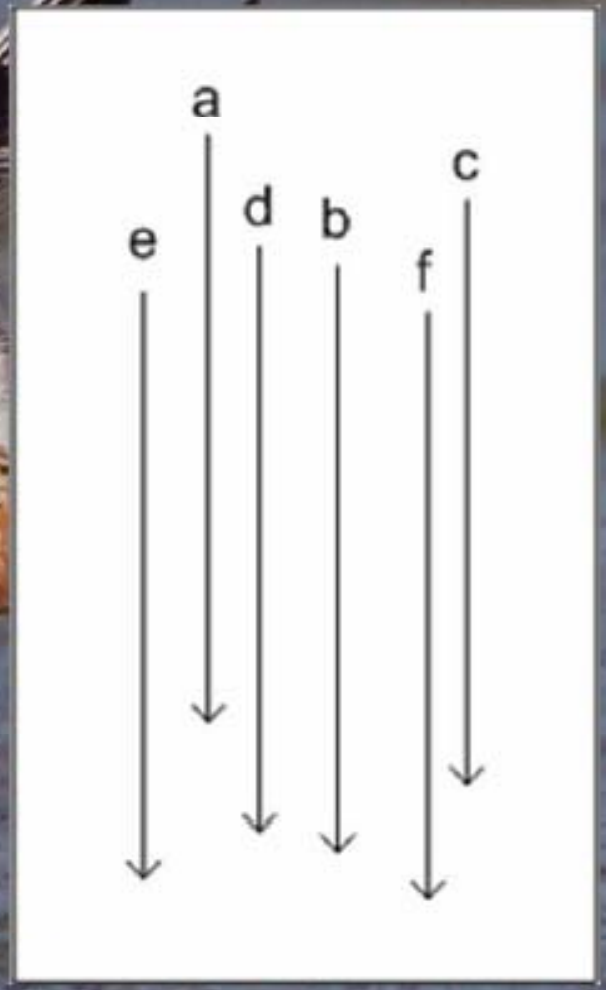
A form of dispersal, movement away from and subsequent return to the same location on an annual basis.

# Migration v. dispersal

Migration: Predictable direction




Dispersal

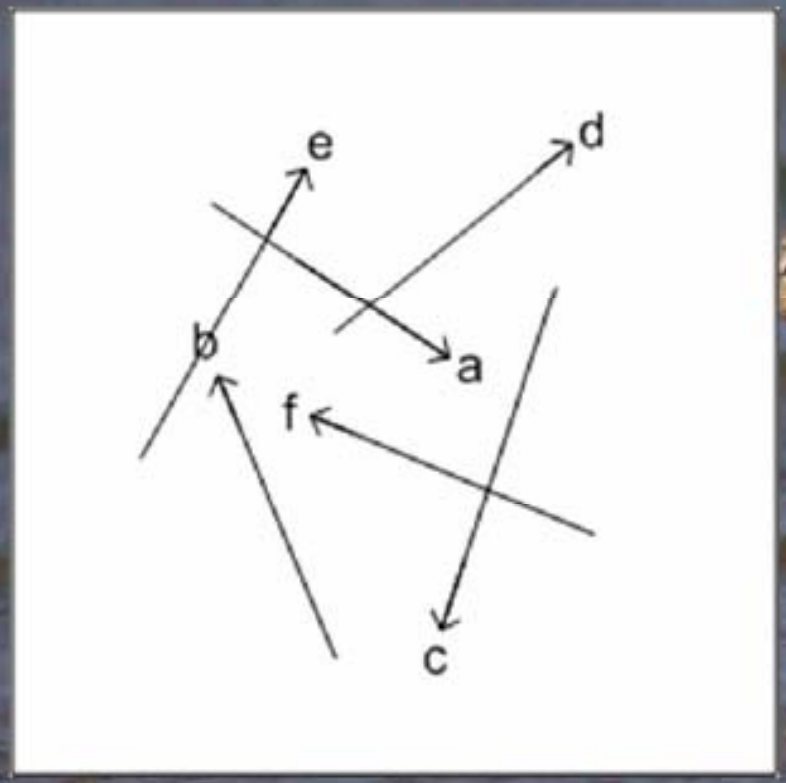



Migration

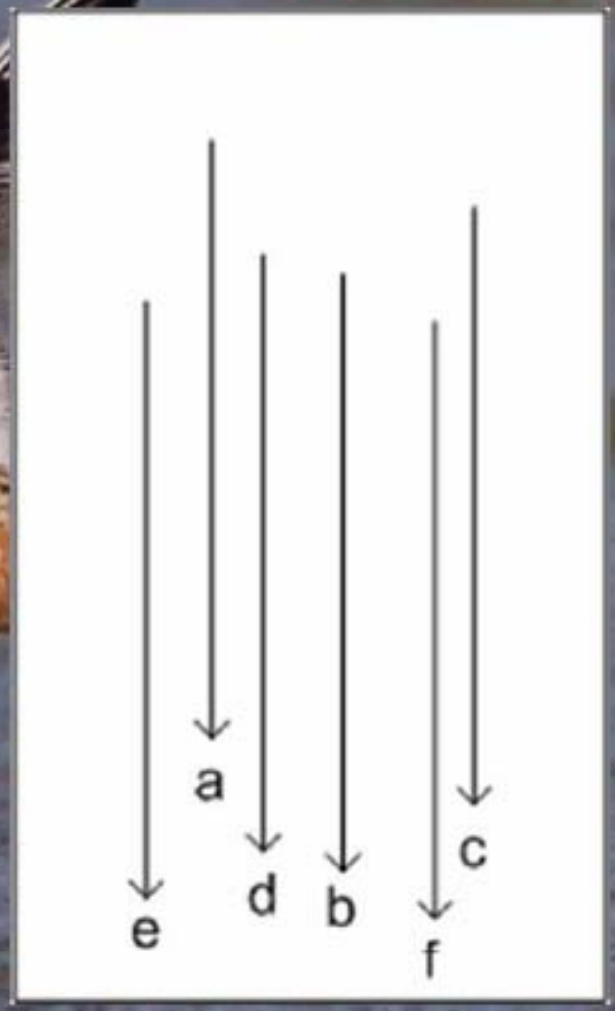
jvverde/Flickr

# Migration v. dispersal

Migration: Return to the same area



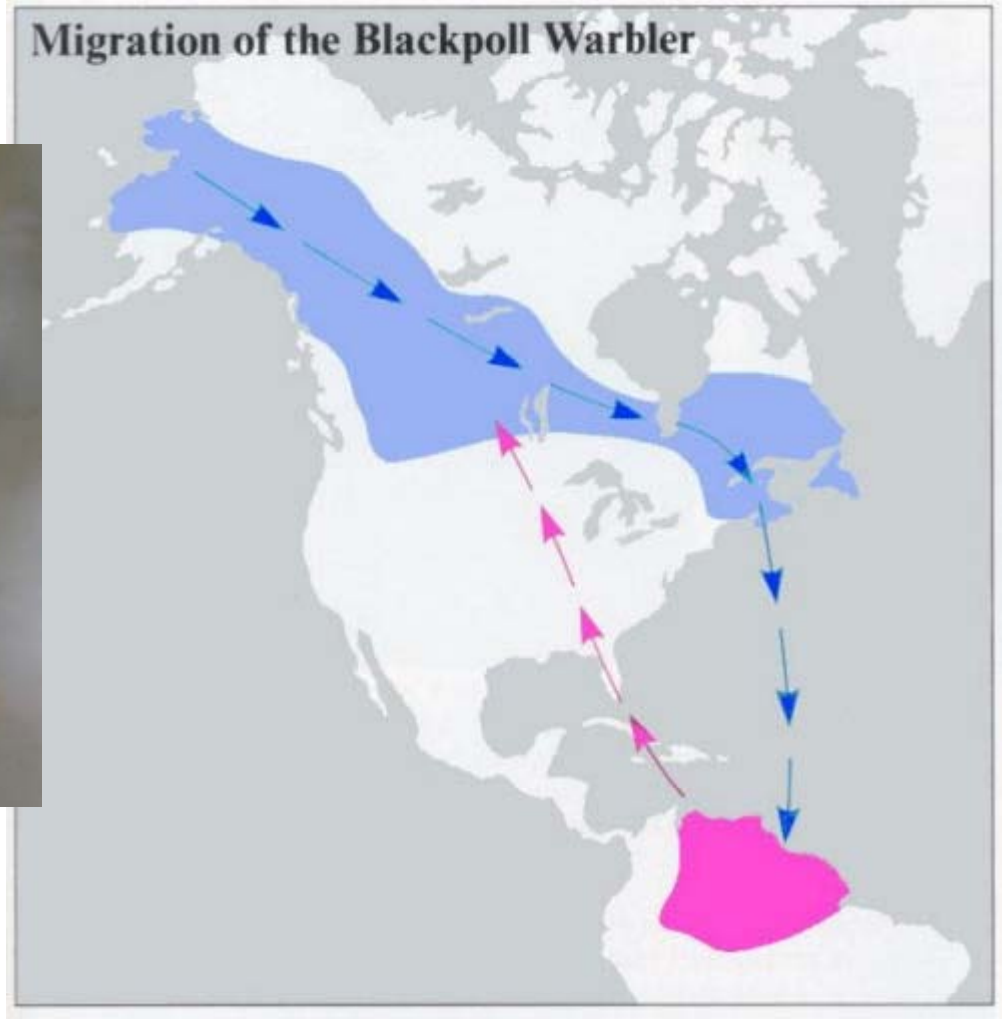

Dispersal




Migration

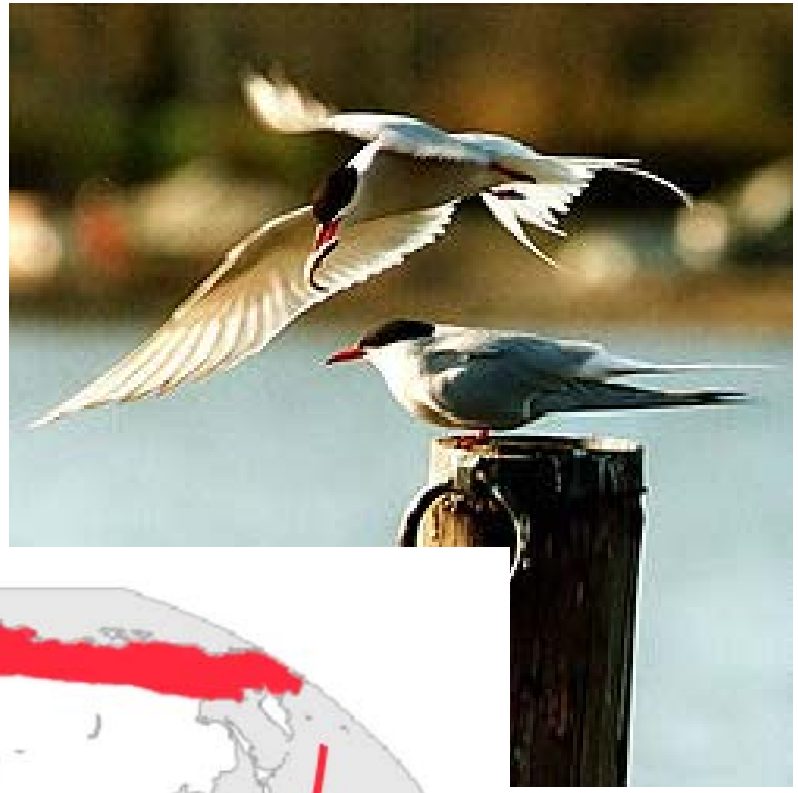
jvverde/Flickr

# Blackpoll Warbler

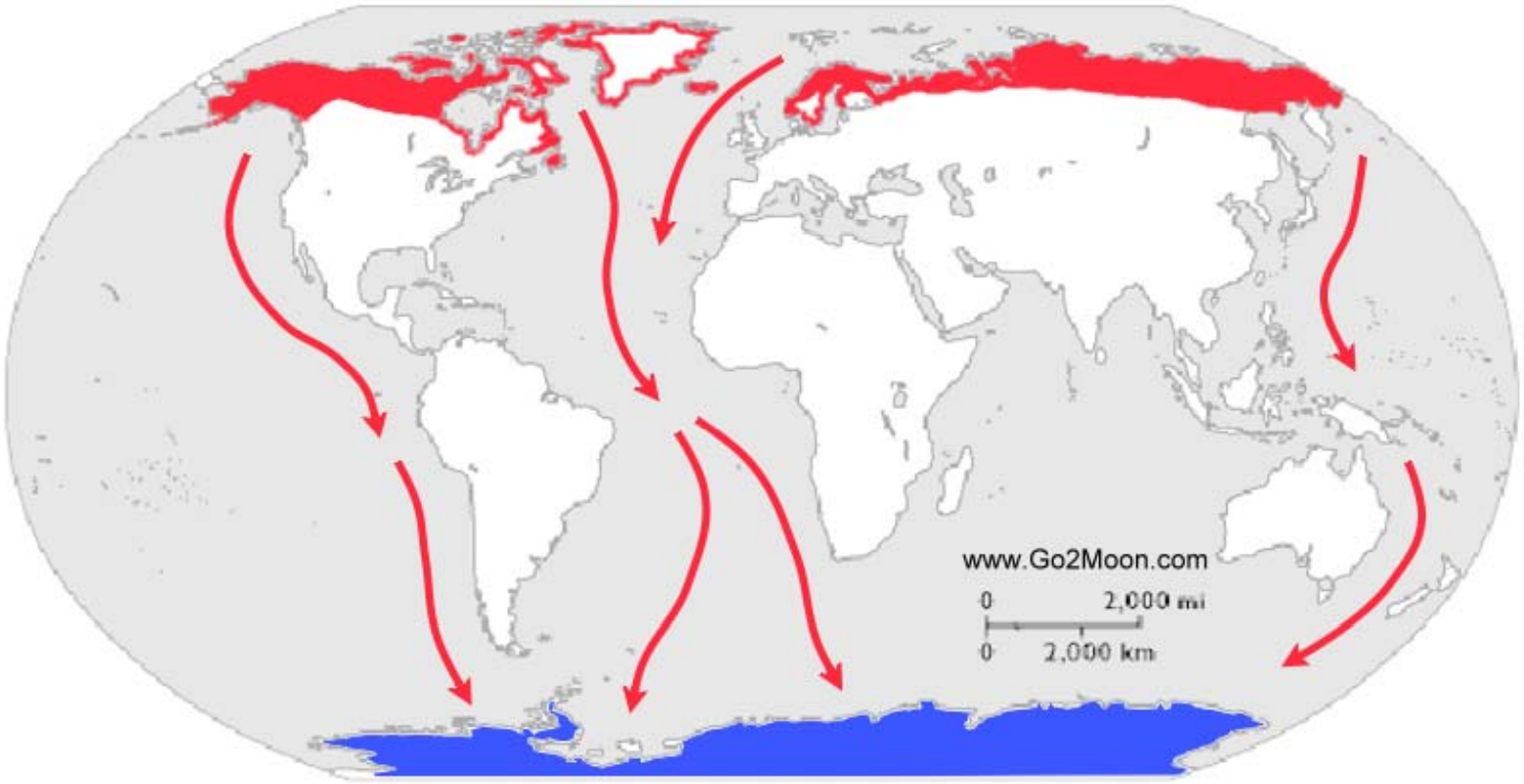



Nearly half of all the breeding birds in NA are migrants

# Arctic tern

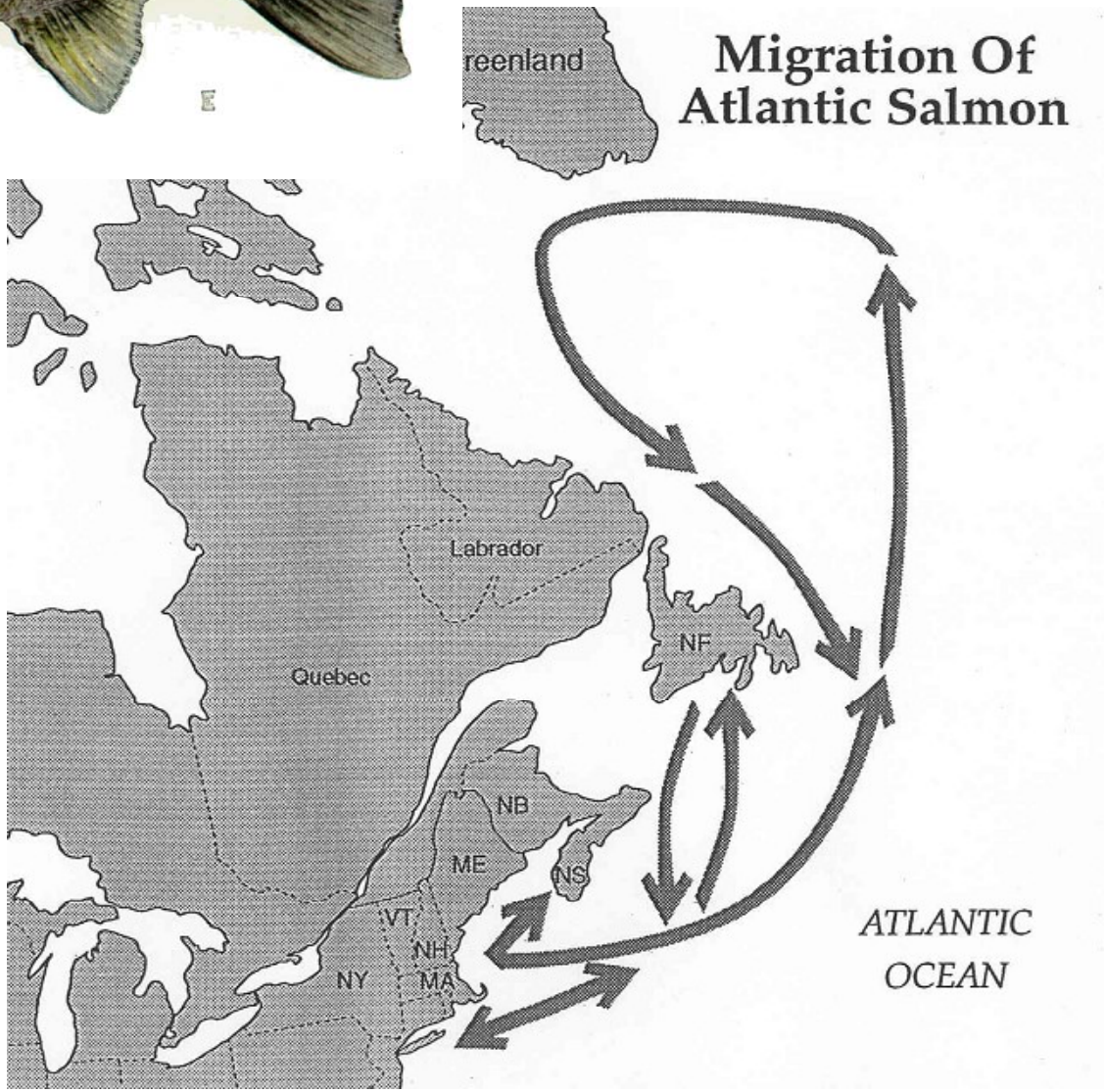


12,000 miles each way

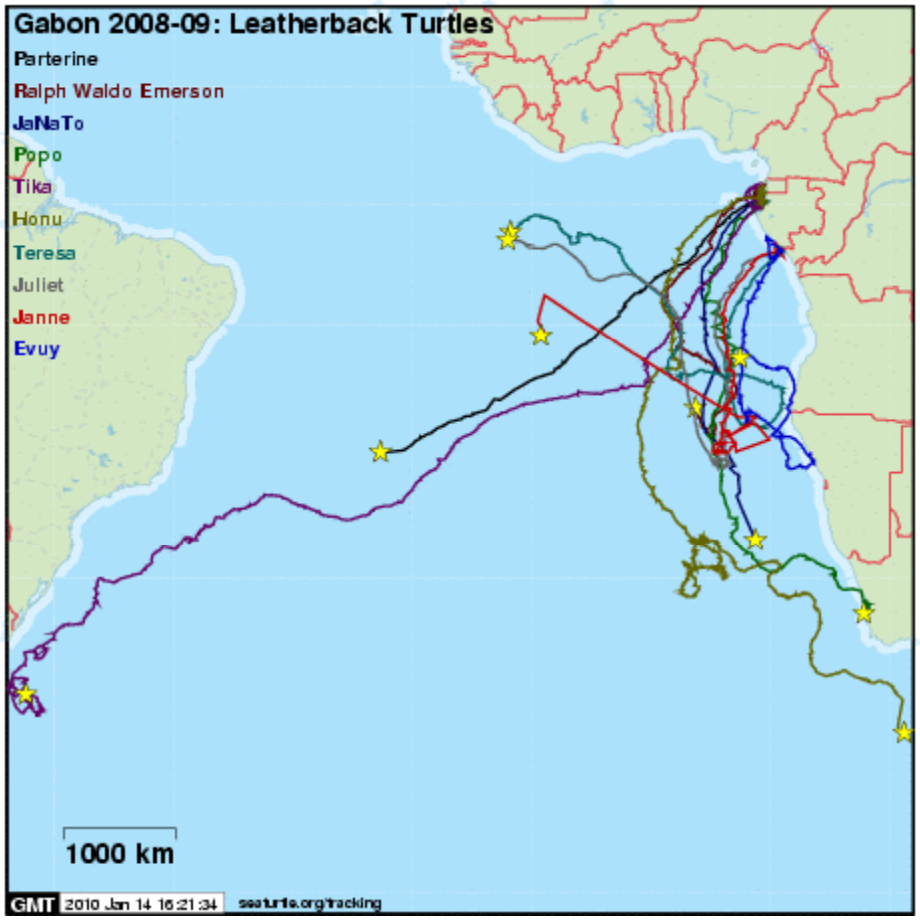


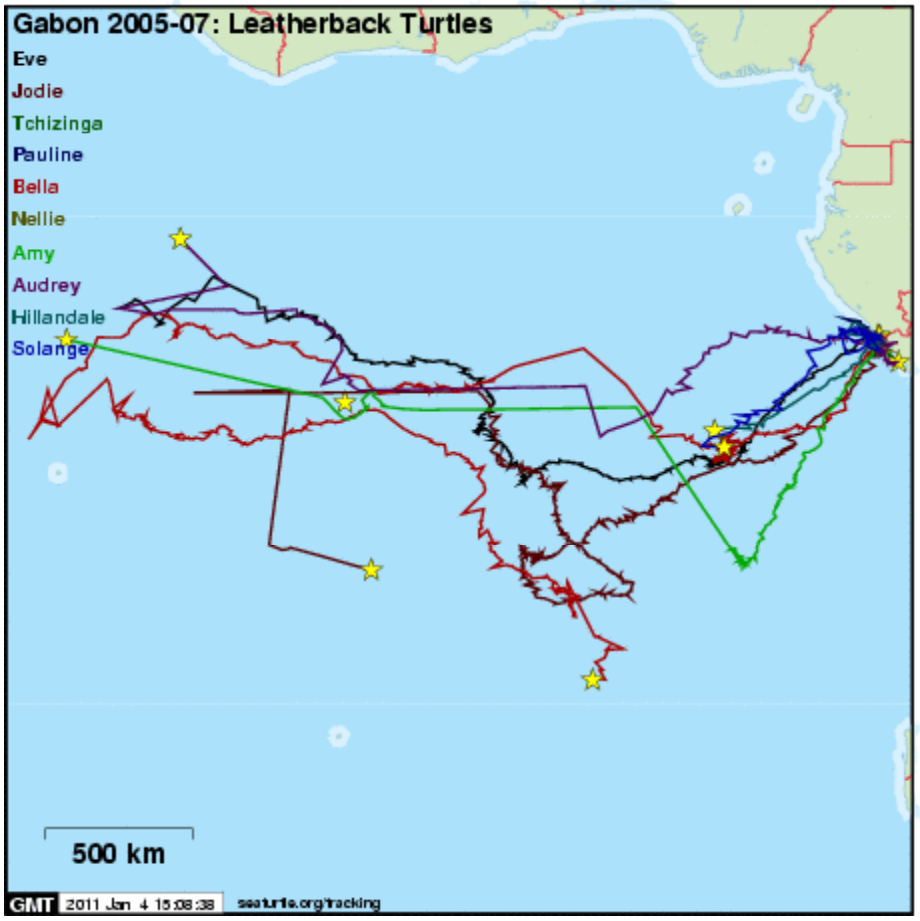
**The animals kingdom's longest migration award goes to the Sooty shearwater-----39,000 miles**

# Atlantic Salmon

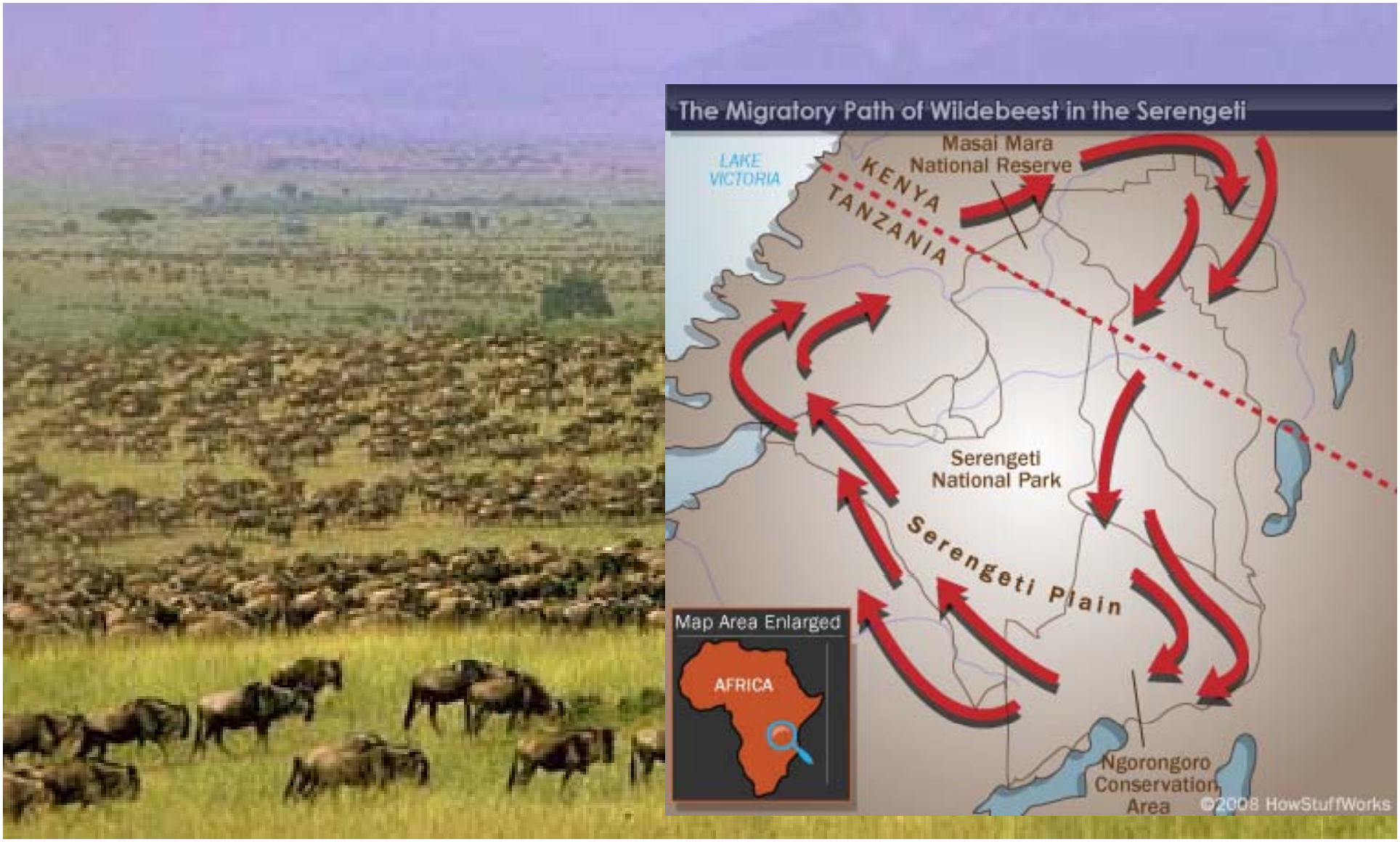


# Loggerhead sea turtle

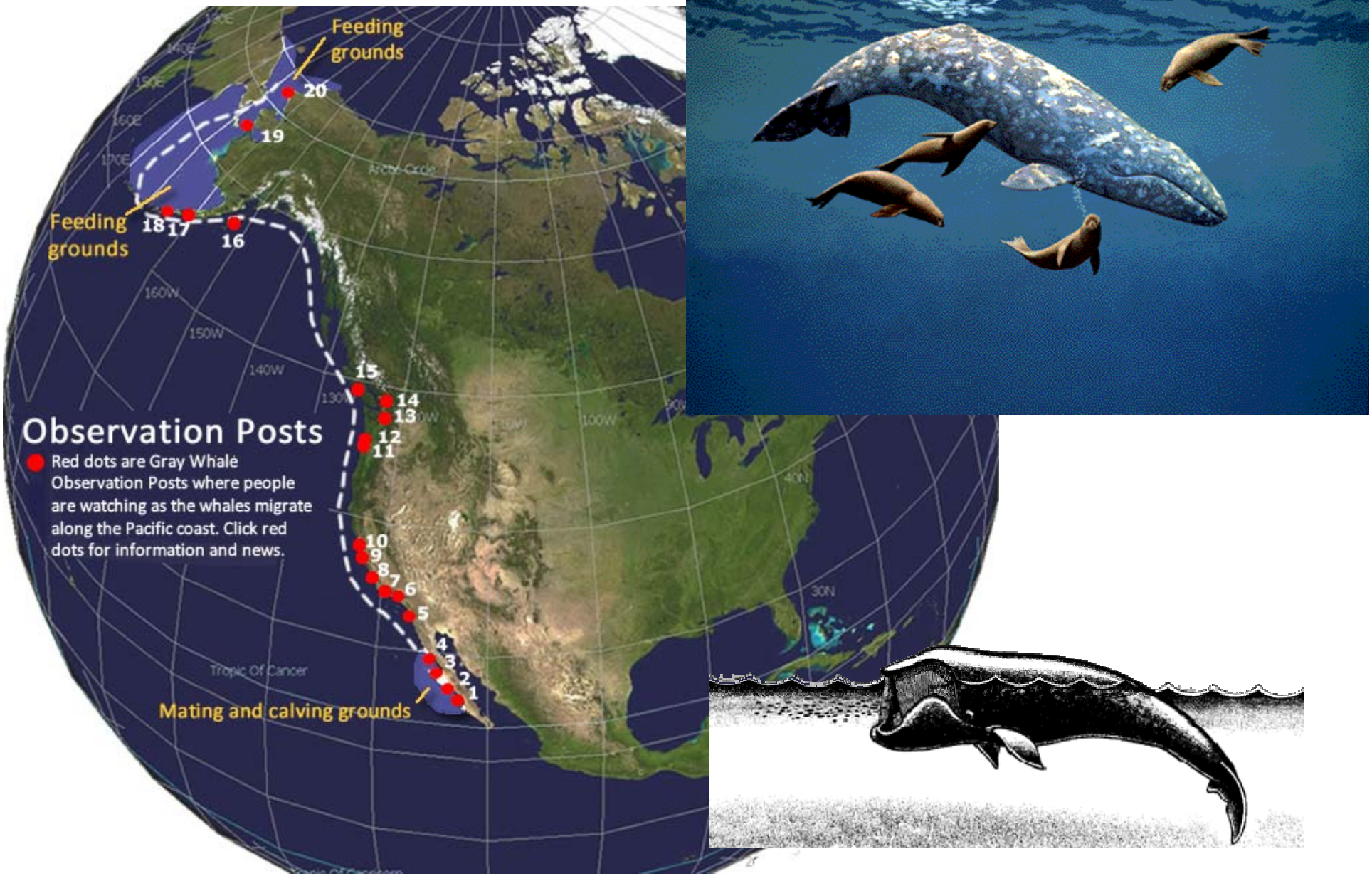



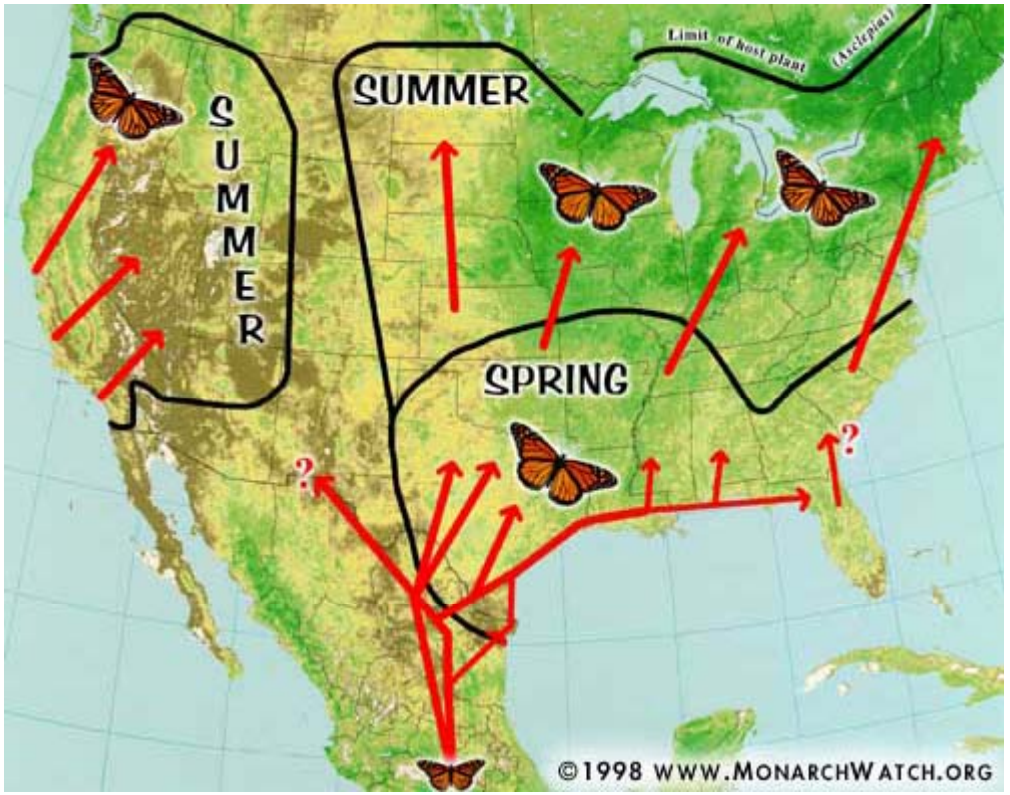
# Wildebeest


The Migratory Path of Wildebeest in the Serengeti
LAKE VICTORIA
KENYA
TANZANIA
Masai Mara National Reserve
Serengeti National Park
Serengeti Plain
Ngorongoro Conservation Area
Map Area Enlarged
AFRICA
©2008 HowStuffWorks

# Gray whale


Feeding grounds
20
19
Feeding grounds
18
17
16
160W
150W
140W
15
14
13
12
11
Observation Posts
Red dots are Gray Whale Observation Posts where people are watching as the whales migrate along the Pacific coast. Click red dots for information and news.
10
9
8
7
6
5
4
3
2
1
Tropic Of Cancer
Mating and calving grounds

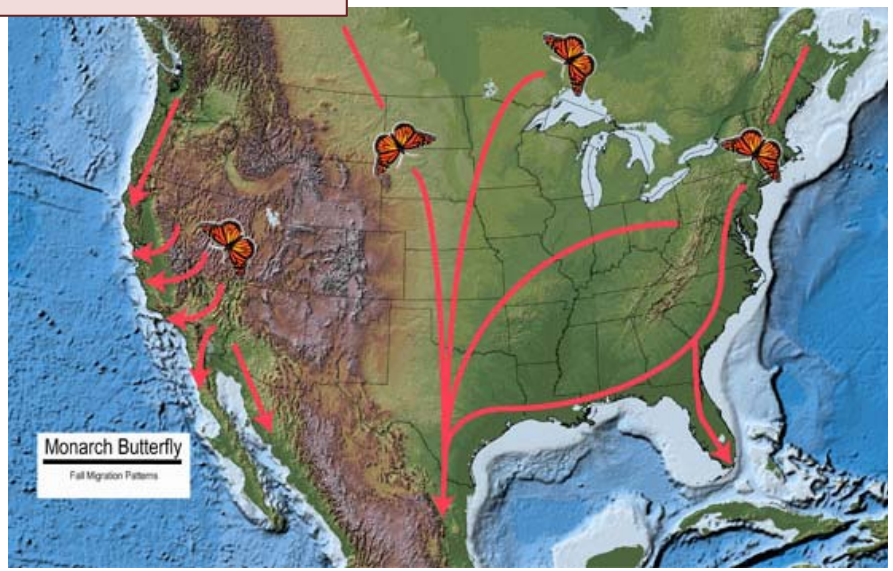
# Monarch butterfly: 3000 miles, multi-generation migration



# Travel South (fall): One generation

Eastern North American monarchs fly south using several flyways then merge into a single flyway in Central Texas.

3600km in 75 days: 50km per days




# Wintering

Overwintering Monarchs clustering on Oyamel trees (2500-3500 m height) in Angangueo, Michoacan, Mexico.


George D. Iepp

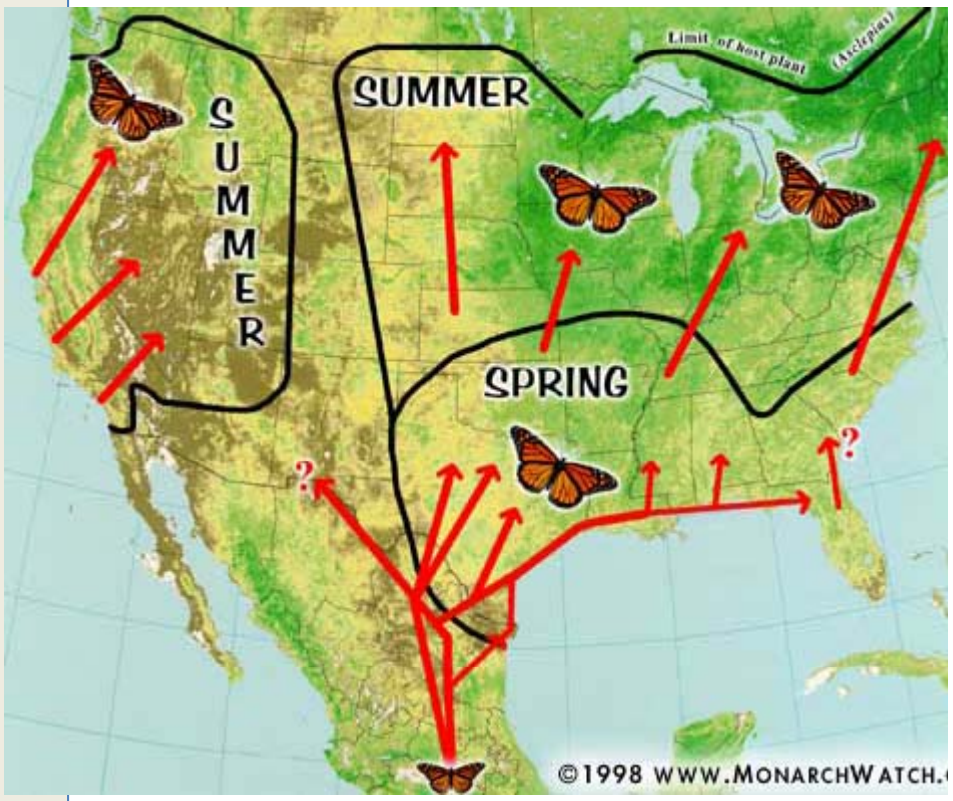
# Travel North (spring): several generations

Early spring, to gulf coast, lay eggs.

Offspring of the first generation → Great lake and southern Canada; lay eggs

Offspring of the second generation → to east; lay eggs

Offspring of the third generation →fall migration



# Why do animals migrate?

## Ultimate causes?

# Why do animals migrate?

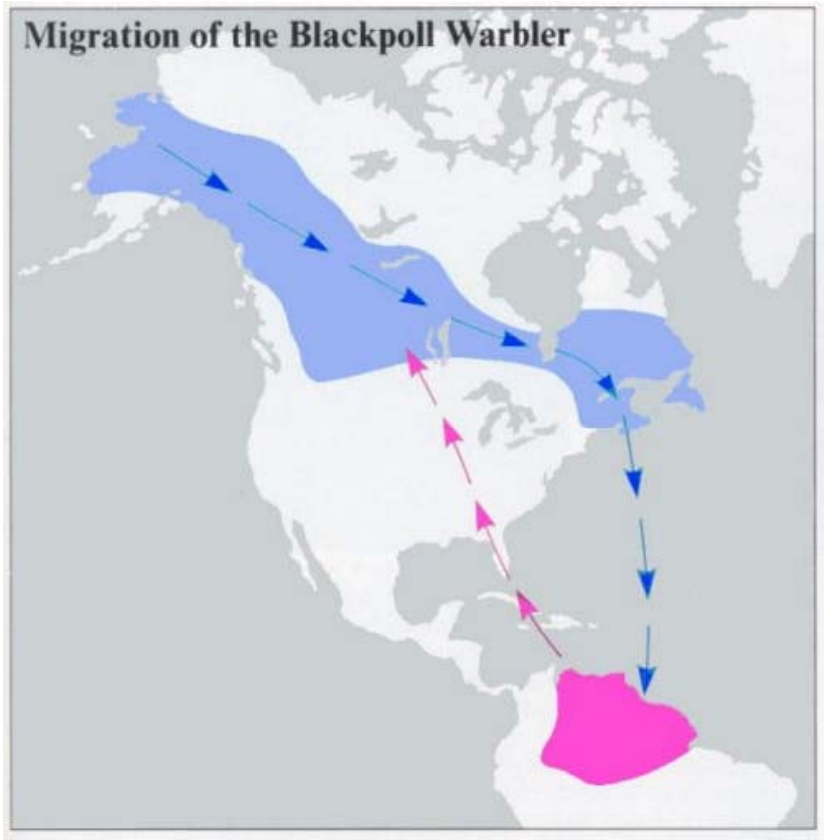
The **benefits** of migration: food and reproduce

1. Abundant food in the north (temperate zone) during summer (insects…).
2. Less predators in the north during summer.
3. Longer hours of summer daylight in the north than staying in tropics.
4. Warmer temperature for wintering in tropics.

# Why do animals migrate?

## The costs of migration

1. Energy: large fat reserve
2. Predator



# Why do animals migrate?

The costs of migration

1. Energy: large fat reserve
2. Predator

Many predators wait at migratory stopover sites to capture exhausted migrants

Migratory behavior:

learned or innate?

# Genetic basis of migratory behavior

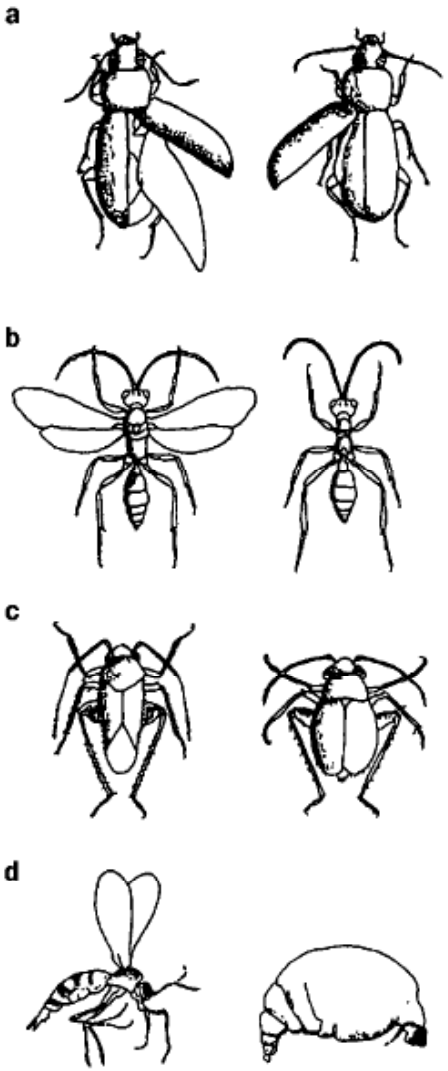



*Figure 3. Four examples of dimorphic variation in wing morphology (flightless morph on the right). (a) In the carabid* Pterostichus anthracinus*, there are no obvious differences between the morphs except for the size of the wings, which are hidden under the elytra (forewings). (b) The winged morph of the hymenopteran* Gelis corruptor *is distinguished both by the presence of wings and by an enlarged thorax. (c) There are major differences in body morphology in the bug* Halticus chrysolepis*. (d) Differences in body morphology are extreme in the dipteran* Plastosciara perniciosa*, even though the two morphs could be siblings. From Roff (1986).*

# Genetic basis of migratory behavior

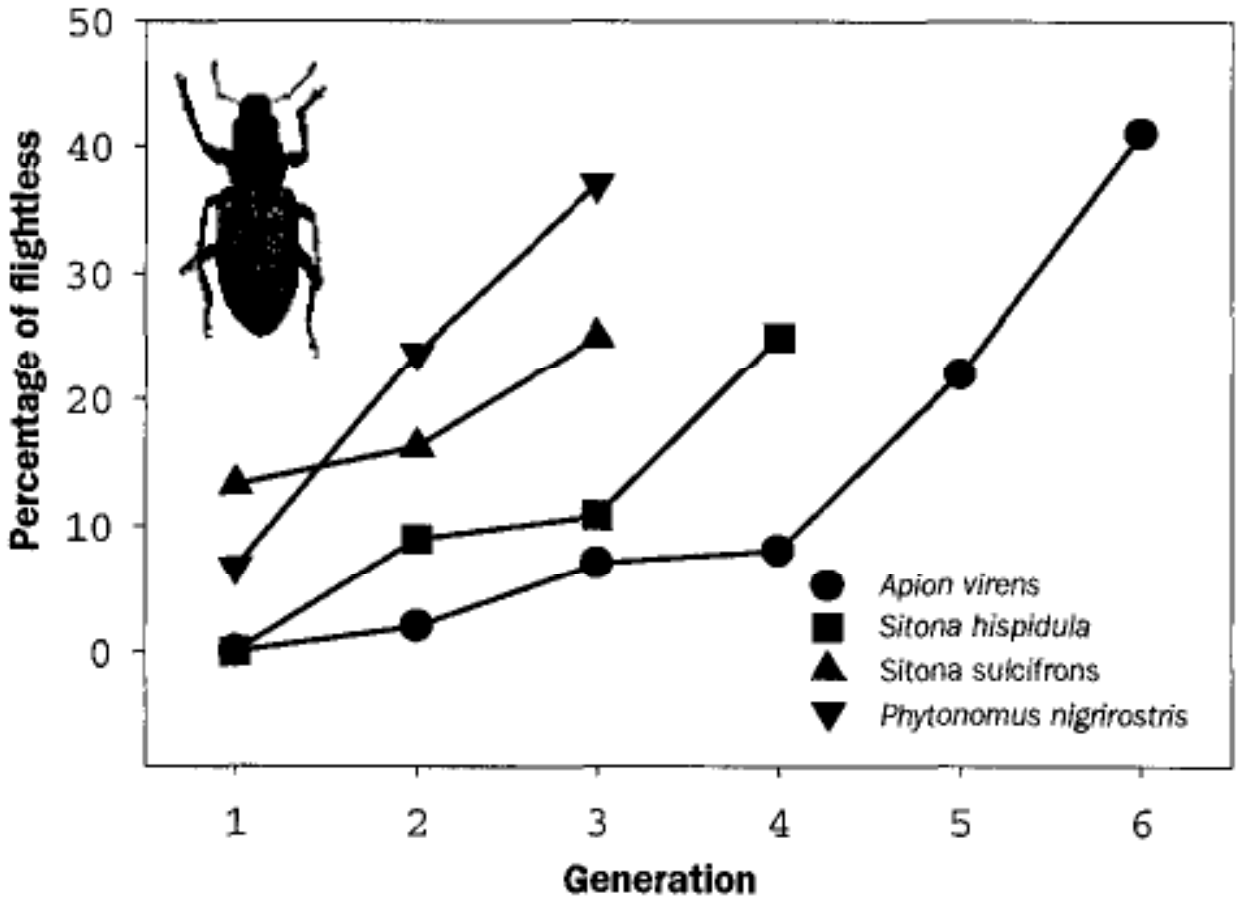
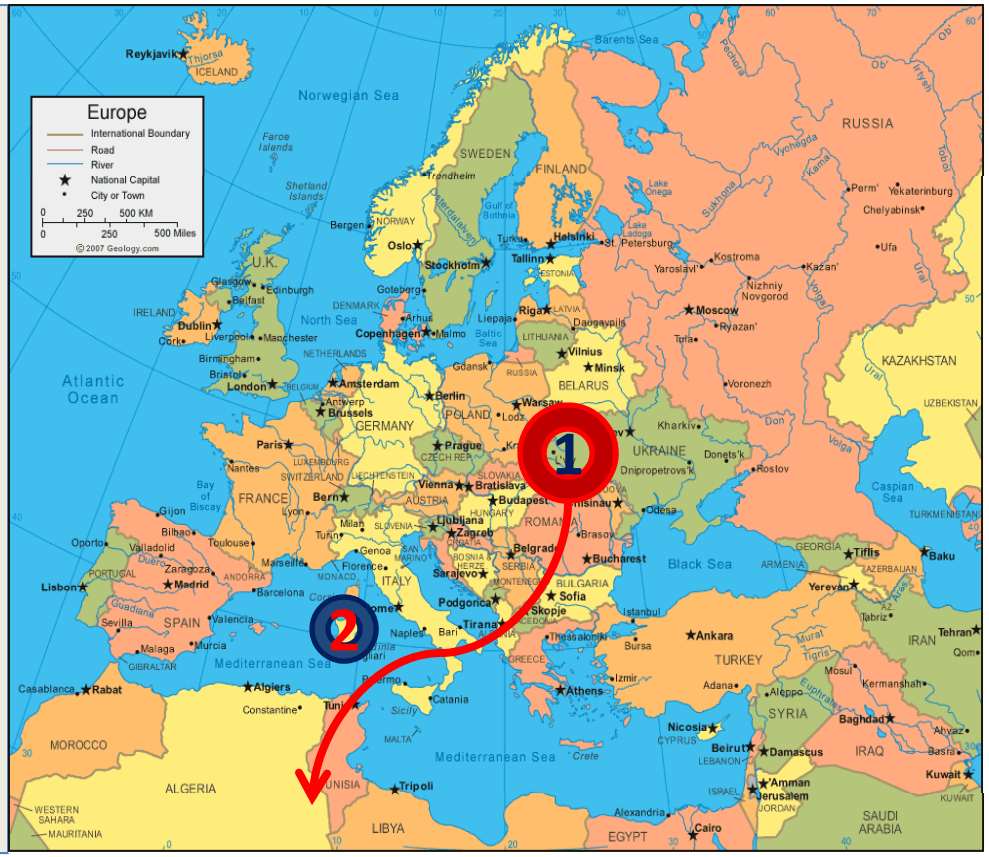



*Figure 1. Increases in the percentage of flightless individuals (brachypters) in four species of weevils following colonization of newly seeded meadows. Data are from Stein*

# Blackcaps: an European warbler

Population #1: fully migratory (central Europe)

Population #2: non-migratory; resident all year long (an island close to Africa)




How do you design an experiment to determine if the migratory behavior is innate or learned?

# Blackcaps: an European warbler

Population #1: fully migratory (central Europe)

Population #2: non-migratory; resident all year long (an island close to Africa)


Cross-breed between migratory and non-migratory ones

What are your predictions??

# Blackcaps: an European warbler

Population #1: fully migratory (central Europe)

Population #2: non-migratory; resident all year long (an island close to Africa)


F1 hybrids (fully migratory x resident) = 40% are migratory
Demonstrate that genetic control of the migratory behavior

Not all of F1 become migratory: not a single genetic locus determines this behavioral trait.

# Blackcaps: Experiment #2

Two populations; both are migratory, both are from central Europe.

But have different migratory routes:

Population 1: southwest route

Population 2: southeastern


~~How do you design an experiment to determine~~ if the migratory behavior is innate or learned?

# Blackcaps: Experiment #2

Two populations; both are migratory, both are from central Europe.

But have different migratory routes:

Population 1: southwest route

Population 2: southeastern


Cross-breed between southwesters and southeasterns

And your predictions??

# Blackcaps: Experiment #2

Two populations; both are migratory,  both are from central Europe.

But have different migratory routes:

Population 1: southwest route

Population 2: southeastern


F1 hybrids (eastern x western migrants) =  intermediate direction

Demonstrate that genetic control of the migratory behavior

# Blackcaps

Not only the direction, but also distance is under genetic control

# Migratory distance is under genetic control

Flight restlessness occurs at the time when birds migrate, the longer the migration route is, the longer the flight restlessness lasts when the bird is kept in the cage

# Proximate mechanisms of migration: Physiological/ behavioral adaptation

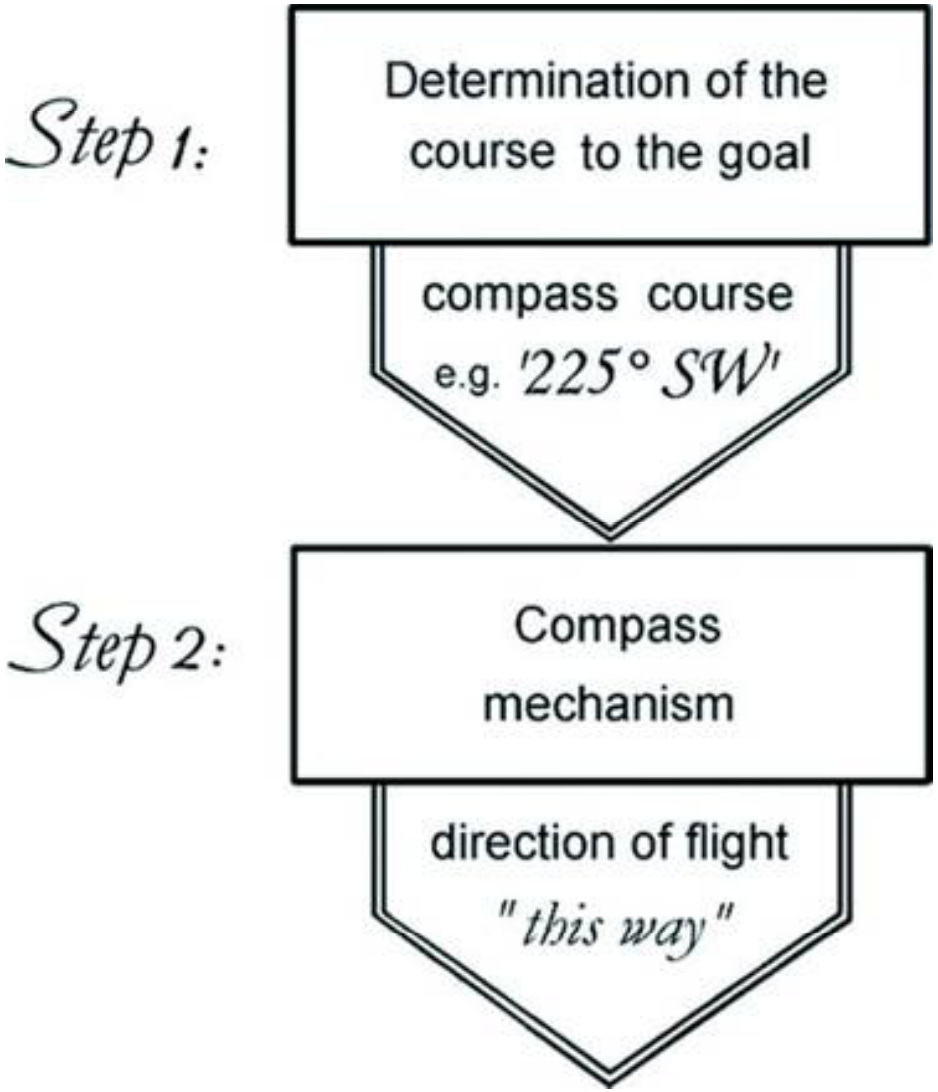
1. Physiological adaptation
   increase body fat 1/3-1/2

2. Behavioral changes
   a. flight restlessness
   b. change diurnal/nocturnal rhythm

# Proximate mechanisms of migration: How do animals migrate? (you need to know where you are, and where are you going to)

Orientation: determine compass direction
Navigation: judge the position while traveling

# Proximate mechanisms of migration: Navigation




1. Landmark
2. Sun compass
3. Star compass
4. Polarized light
5. Magnetic field
6. Odor

# 1. Landmark


Design an experiment to determine how landmark guide navigation?

# 2. Sun Compass

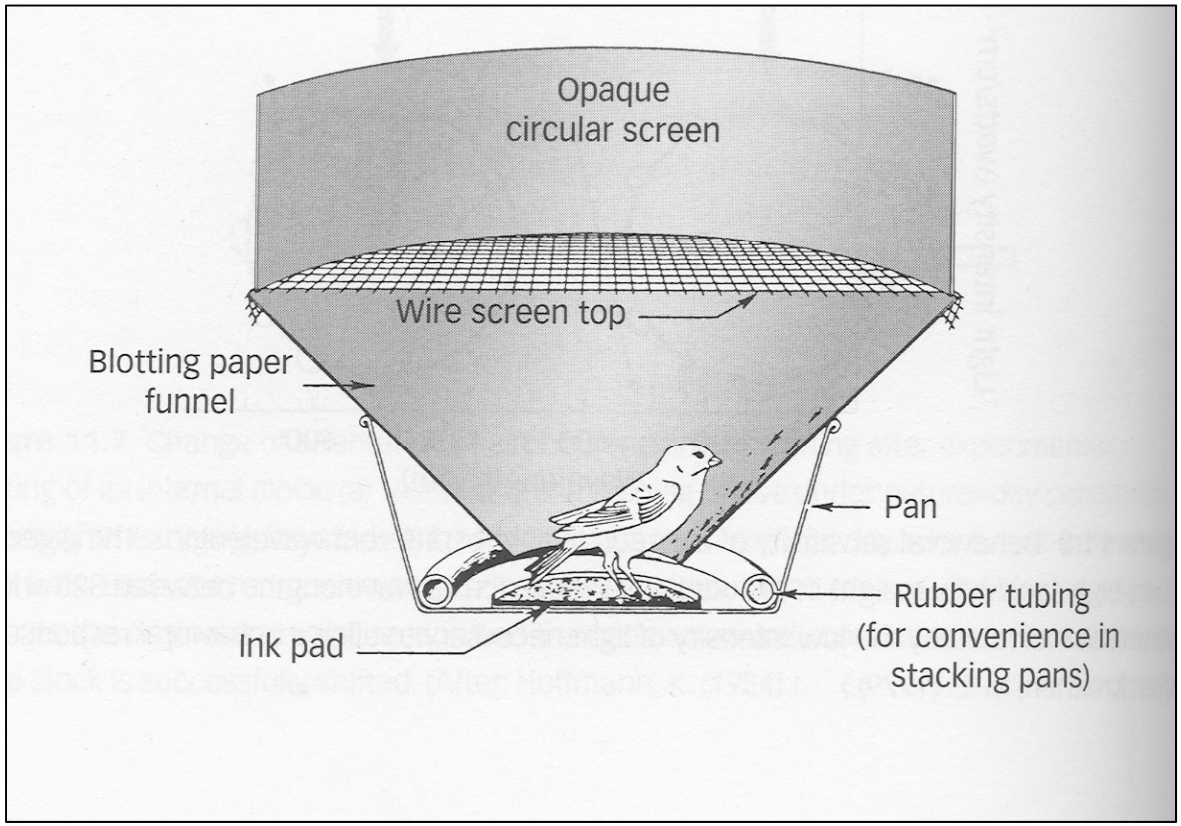
Sun compass: animals can use the position of the sun for orientation

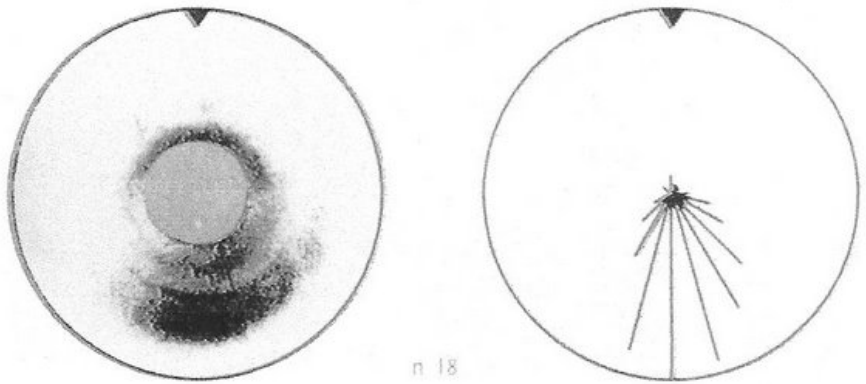
Design an experiment to determine how sun compass guide migration?

# 1. Sun compass

Keep migratory birds in cages, where they can see the sun, record the direction and flight restlessness at the time they usually migrate.

# 1. Laboratory setup to test orientation

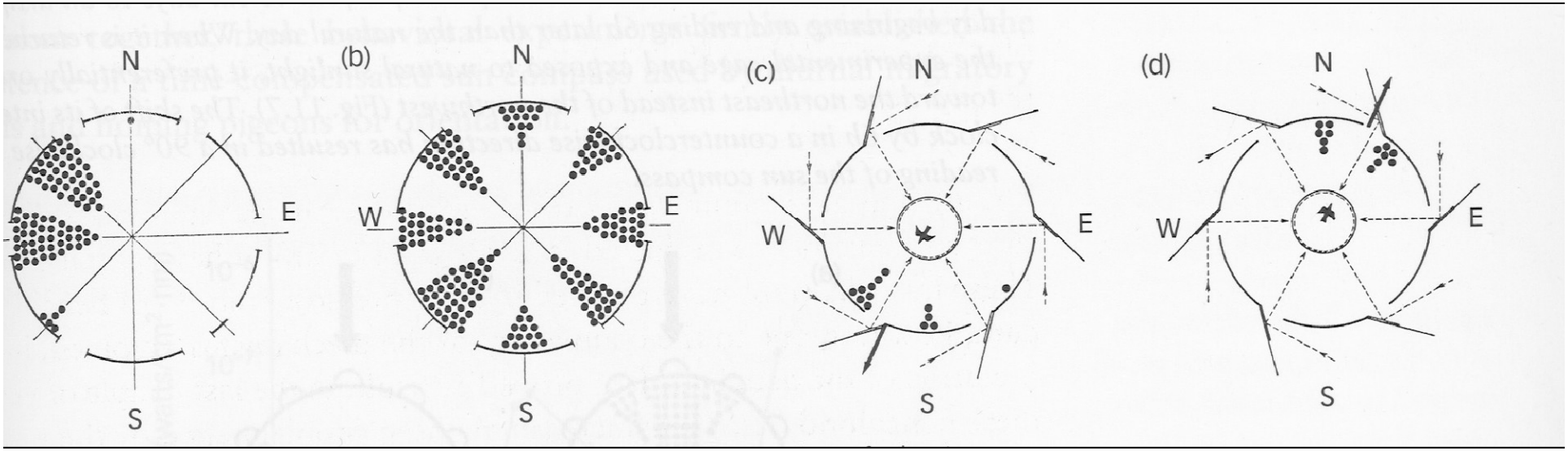


# 1. Laboratory setup to test orientation

**European starling**

# Sun compass




Sun | Overcast | Mirror-deflected 90 degree | Mirror deflected 90 degree

# Many diurnal birds migrate at night

William Cochran (1967) captured a migrating Gray-cheeked thrush in Illinois and attached a tiny radio transmitter to it. At dusk, the thrush took off, followed by the ornithologist in a small plane. A severe thunderstorm and shortage of fuel forced their plane down that night, but the thrush flew on. After refueling, they relocated the bird in the vast night sky. The thrush landed at dawn in Wisconsin after flying 650 km on a firm compass bearing all night.

How to test nocturnal migrants migrate at night (and use what cues) ?

Keep the migrants in cages:

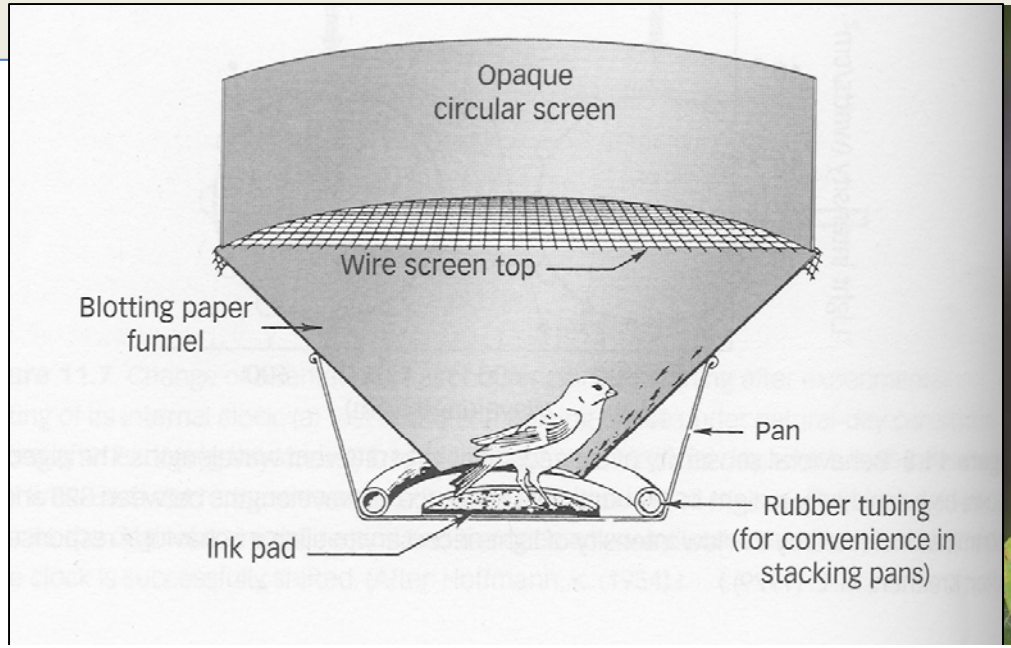
1. When kept indoors, they seem disoriented.
2. When kept in the same cage outdoors, they could see the sky. They are oriented!

## Star compass

# Design an experiment to test birds can use “star compass”.

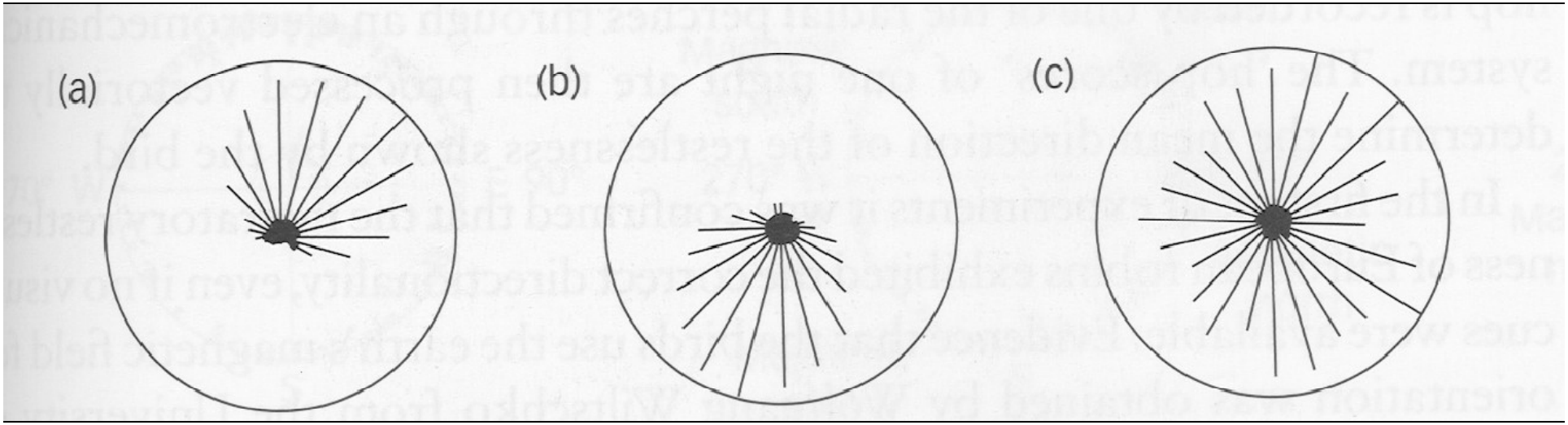
Keep the migrants in a cage (ink pad on the bottom):

1. Birds oriented under natural night sky.




Keep the migrants in a cage:

1. Birds orient under natural night sky
2. Birds oriented the same direction under the stationary sky of a planetarium.




| Spring planetarium sky | Spring planetarium sky, rotate 180 degree | Control group, No star. |
|---|---|---|

Birds learn to recognize
star compass

Juveniles learn to read the star compass in a “sensitive period” before migration

Sun and star compass used to determine the direction of orientation.

Many migratory birds maintain the correct orientation, even if the sky is obscured by clouds (can’t read sun or stars)

Magnet compass

**Figure 1 | Animal magnetism.** Diverse species have magnetic compasses, including (clockwise from top left) the European robin, the loggerhead sea turtle, the brown bat, the Caribbean spiny lobster and the red-spotted newt. A few, including turtles, lobsters and newts, also have magnetic maps.

# Cows can sense magnetic field

Researchers have found that when grazing or resting, cattle and deer tend to point their bodies toward Earth's magnetic poles, which suggests they are able to sense magnetic fields in the same way as many smaller animals.

German and Czech researchers used Google Earth satellite images to look at 8,510 domestic cattle in 308 pastures located randomly across six continents. They also studied body alignment in 2,974 red and roe deer i the Czech Republic, either by photographing the anima or checking the impressions they left in snow.

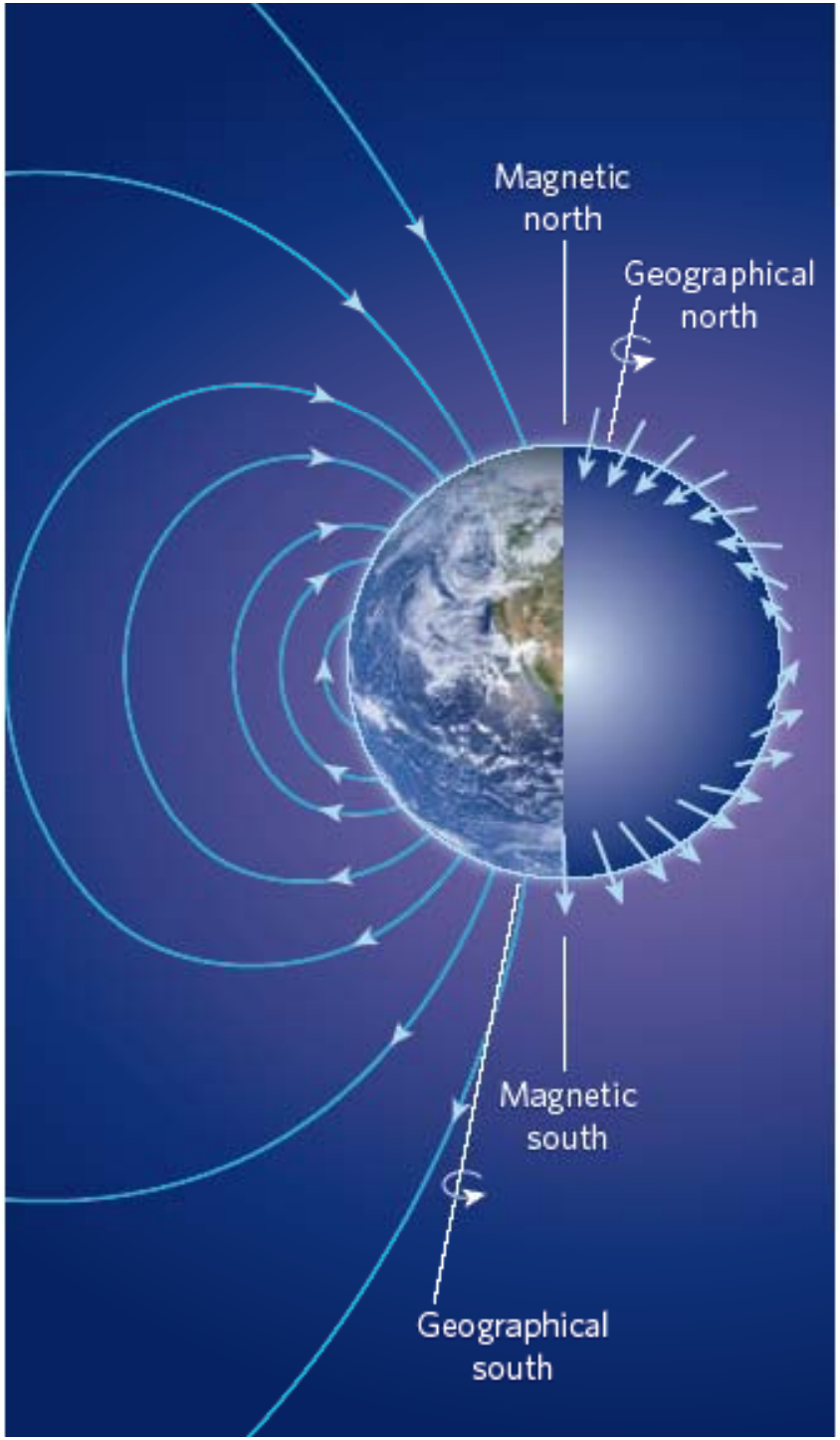
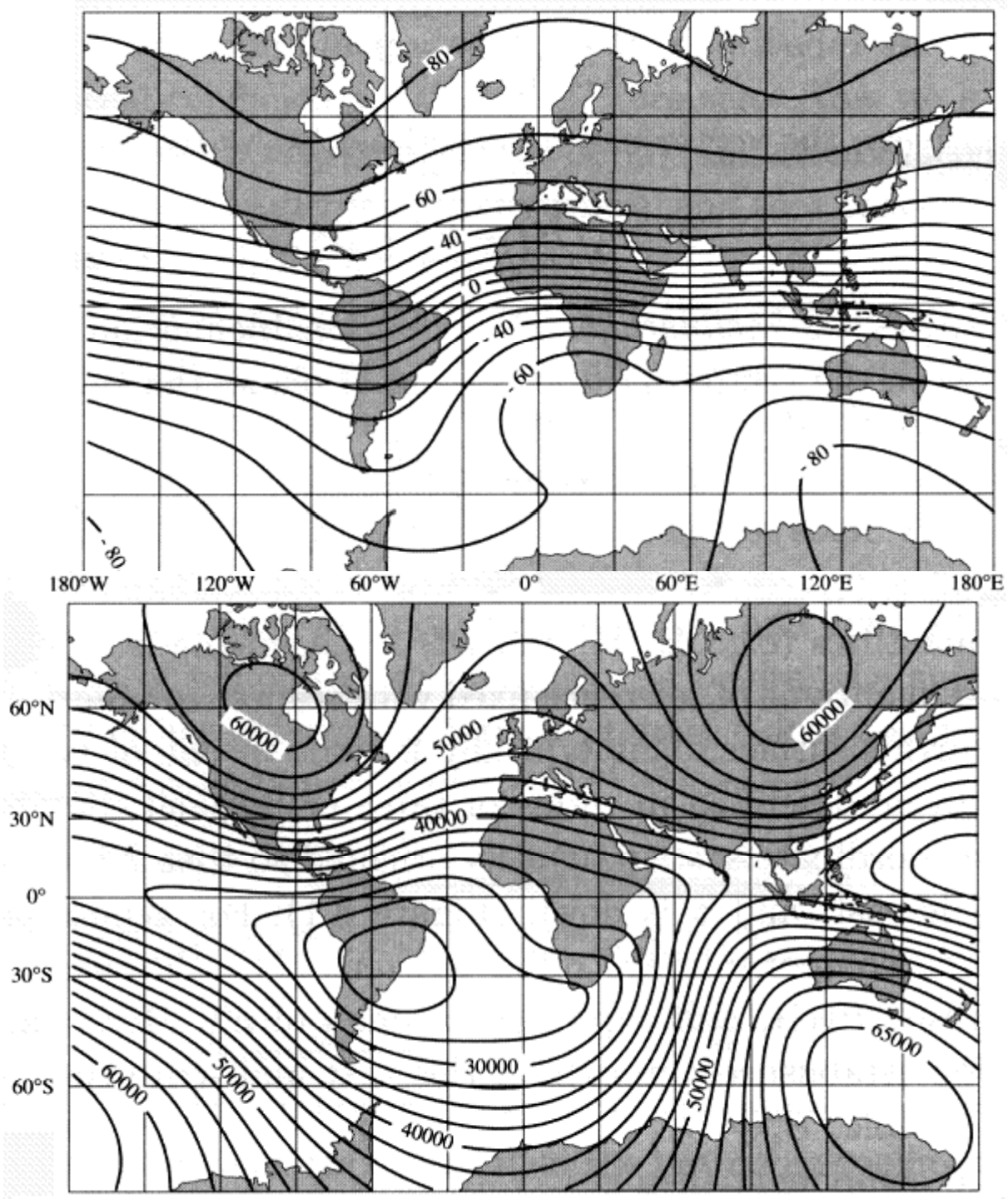
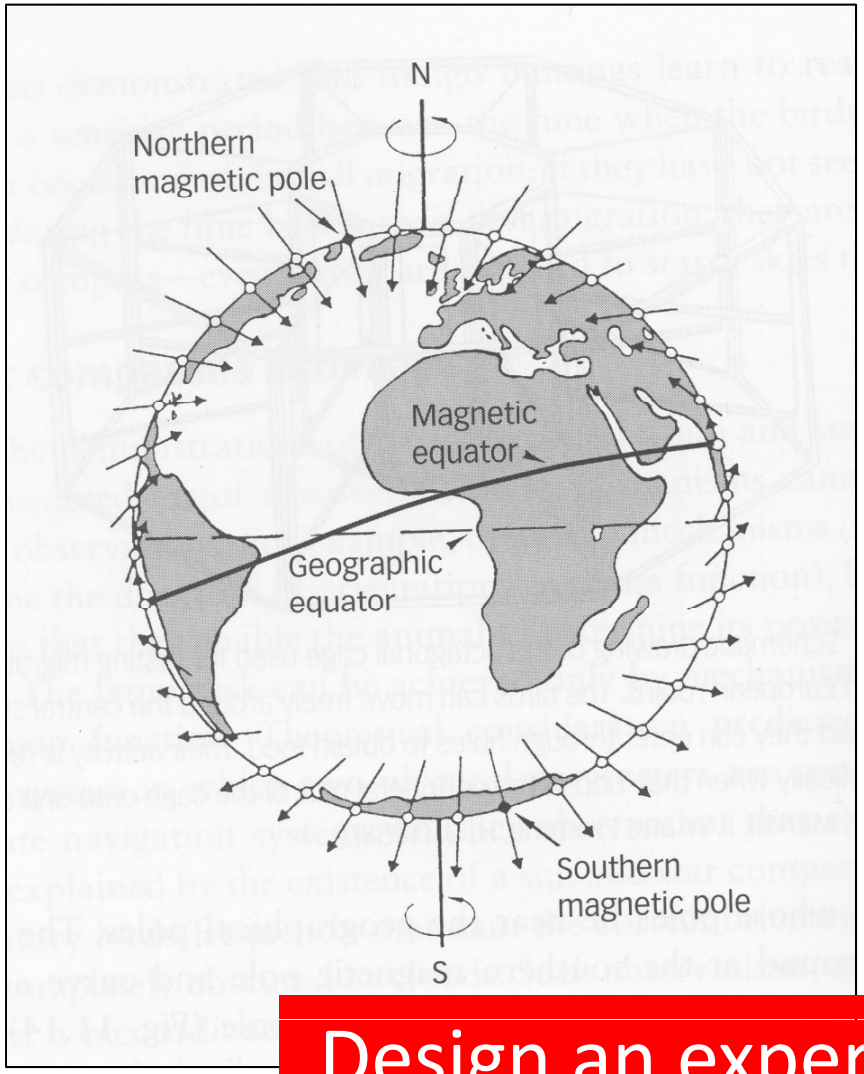



**Figure 2 | Earth's magnetic field.** Field lines emerge from the Southern Hemisphere, wrap around the globe, and re-enter Earth in the Northern Hemisphere. Field lines are parallel to Earth's surface at the geomagnetic equator, but become progressively steeper as an animal migrates towards the poles. Field intensity also varies predictably across Earth's surface. Thus, different geographical regions often have unique 'magnetic signatures' consisting of specific combinations of field-line inclination and intensity, as indicated by the angle and length of the arrows on the right. Animals that have magnetic maps can exploit such information when navigating to particular areas. (Reproduced from T. Alerstam *Nature* 421, 27–28; 2003.)

# Magnetic signature

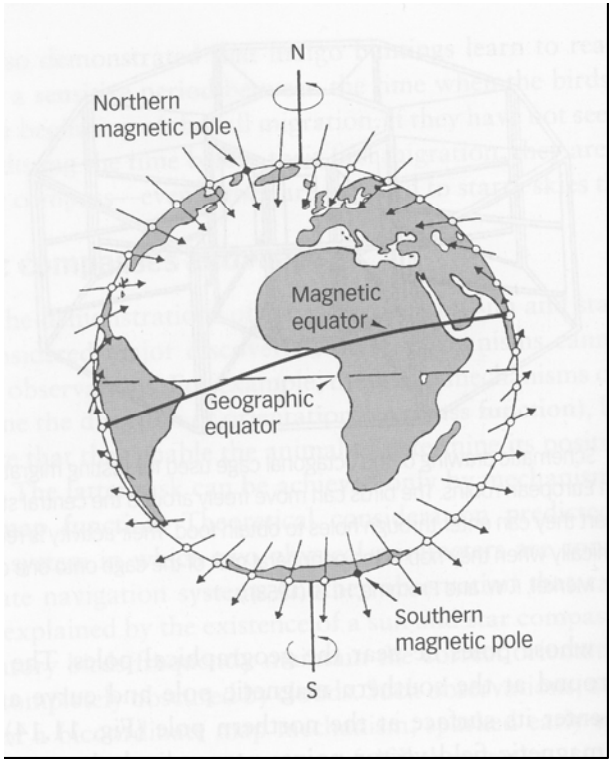


# Magnet compass



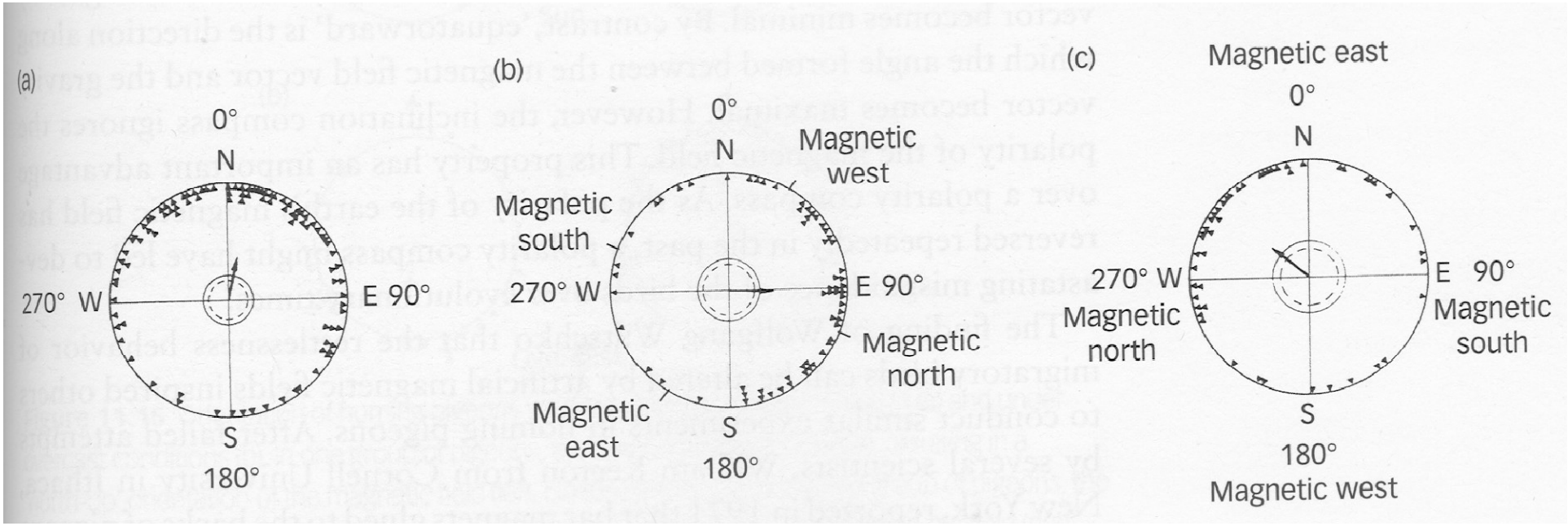

Geographic north/south
is different from
Magnetic north/south

Design an experiment to determine if magnetic field guides orientation?




# Magnet compass

Change the magnetic field, birds change their orientation

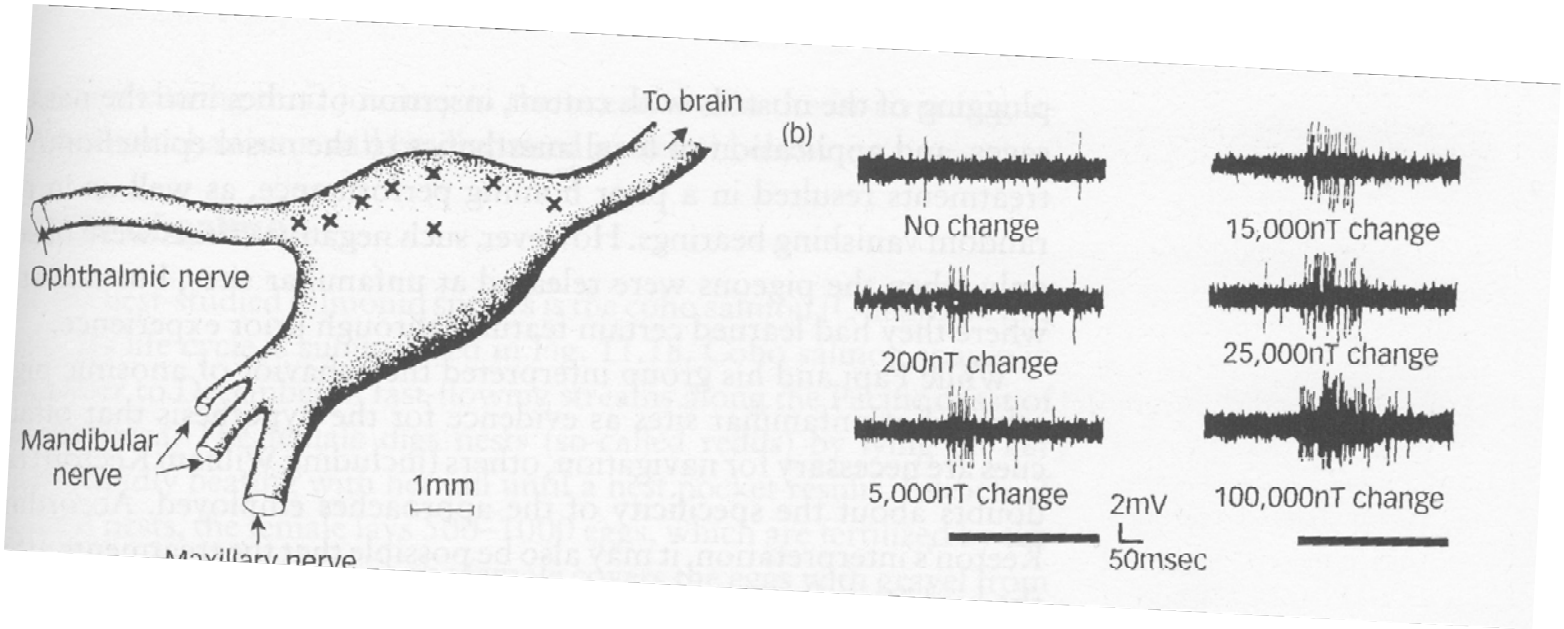


# How do animals perceive magnetic field?

1. Magnetic particles (magnetite)

2. Cryptochrome
   (light-photoreceptor protein)

Many animals have magnetic particles in the neurons to detect the magnetic field



# Olfactory map:
# smell their way home

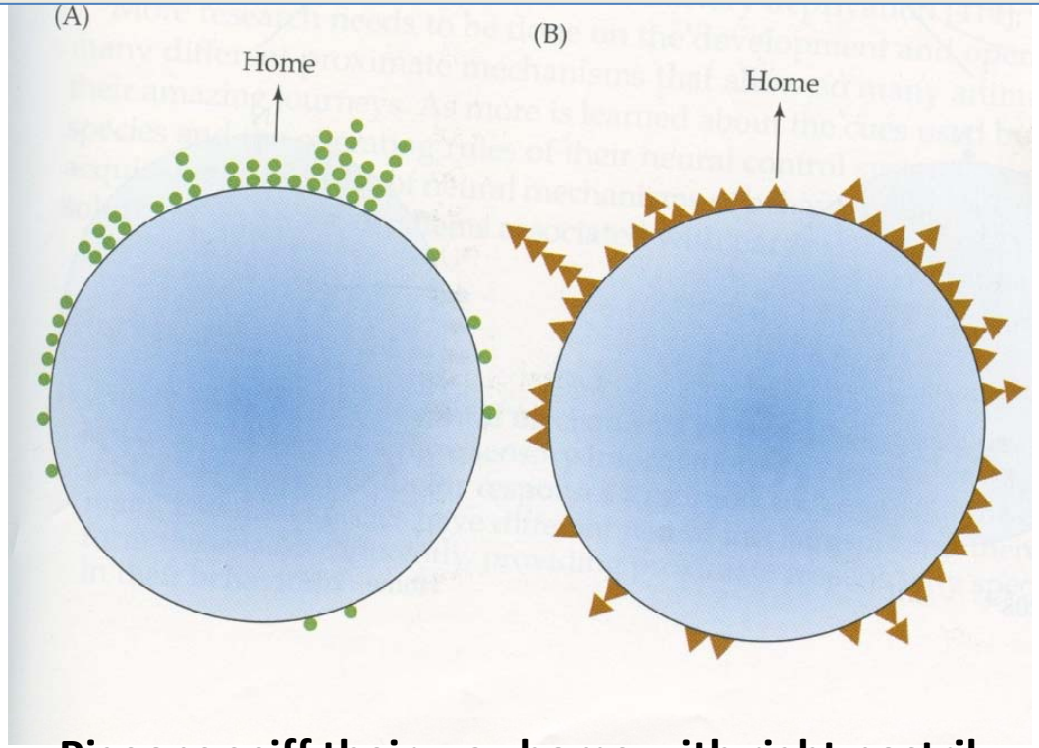
Different locations have different odors;

A north wind and a west wind would each have a distinctive odor

**Design an experiment to determine if olfactory map guides orientation?**

# Olfactory map:

Pigeons with blocked olfaction were much less likely to orient accurately toward the home loft on release

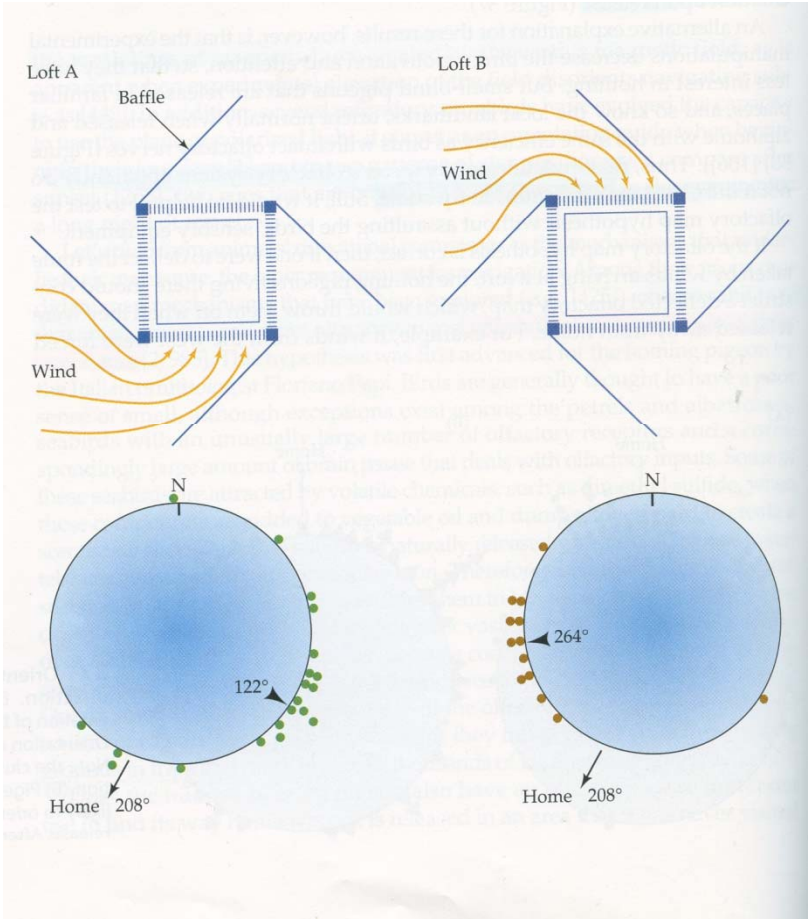



**Pigeons sniff their way home with right nostril**

# Further test of olfactory hypothesis

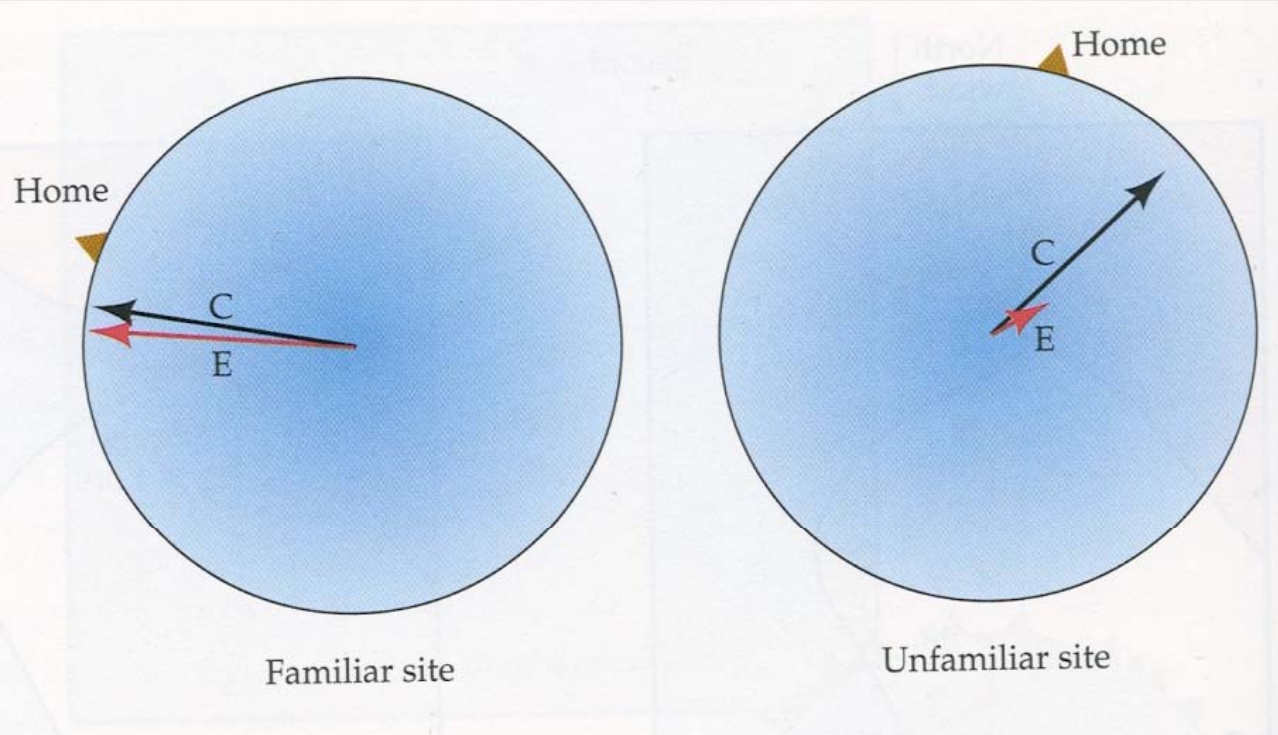
Baffles deflect the wind 90 degree,

alter pigeon's perceptions of the direction of odors



# However,

The effect of blocking olfaction on orientation occurs only if pigeons were released at an unfamiliar site.



## Conclusion:

Many animals can use a combination of compass for orientation or migration.

Sun compass

Star compass

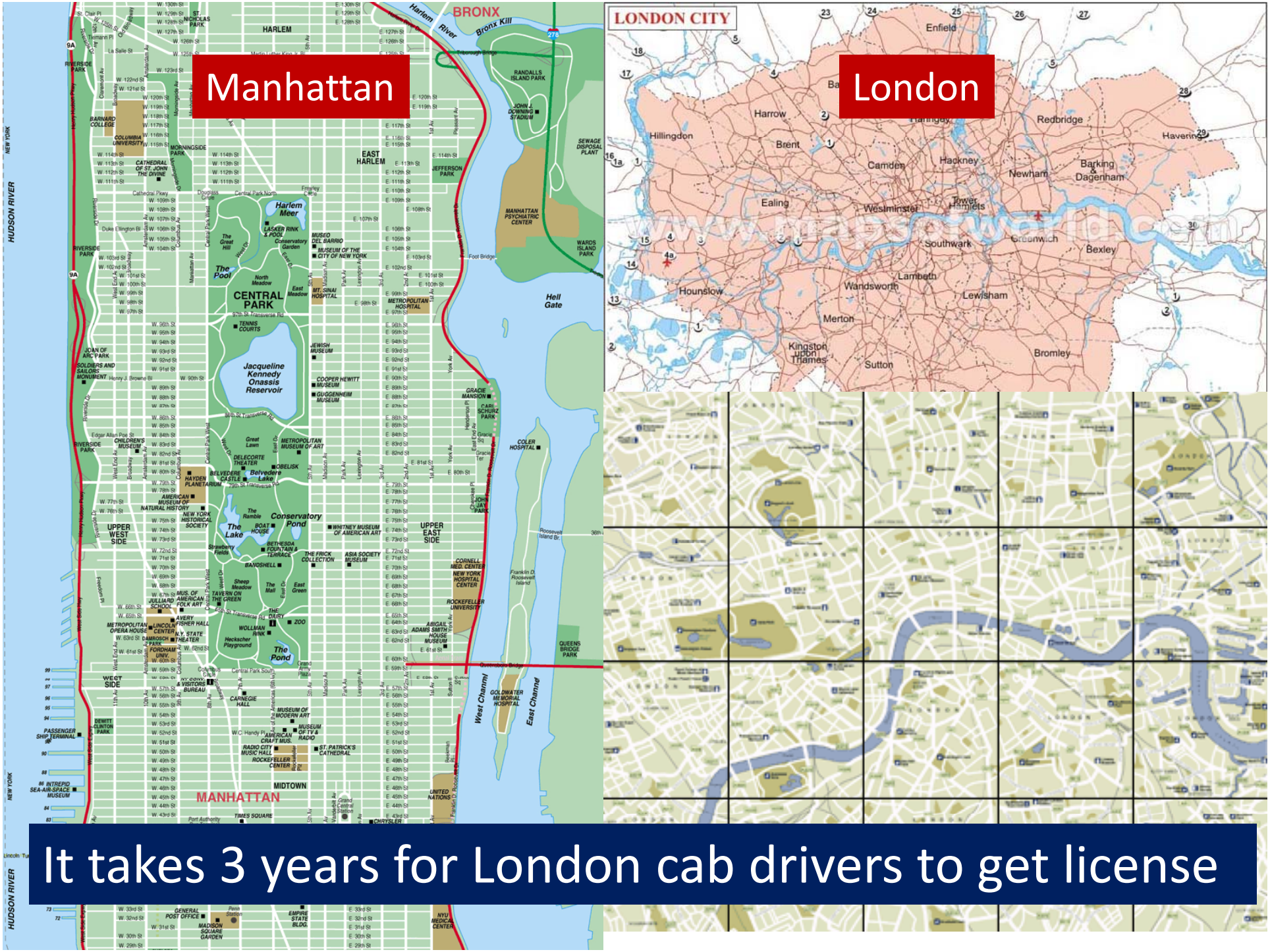
Polarized light

Magnet compass

Olfactory map

Landmark

# Human navigation




It takes 3 years for London cab drivers to get license

# Taxi drivers' brains 'grow' on the job

Taxi drivers given brain scans had a larger hippocampus compared with other people, part of the hippocampus grew larger as the taxi drivers spent more time in the job

# Navigation-related structural change in the hippocampi of taxi drivers

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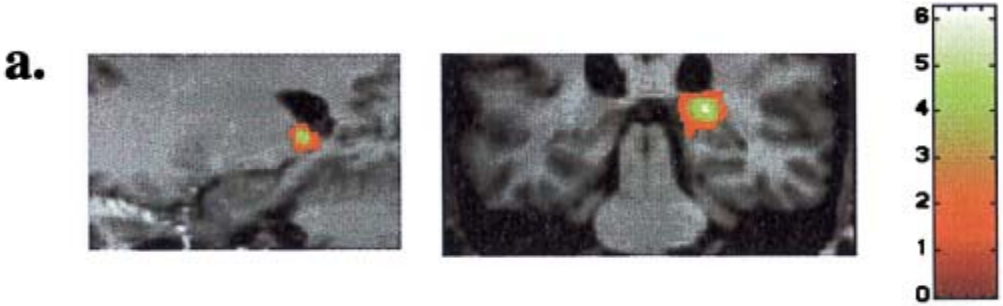


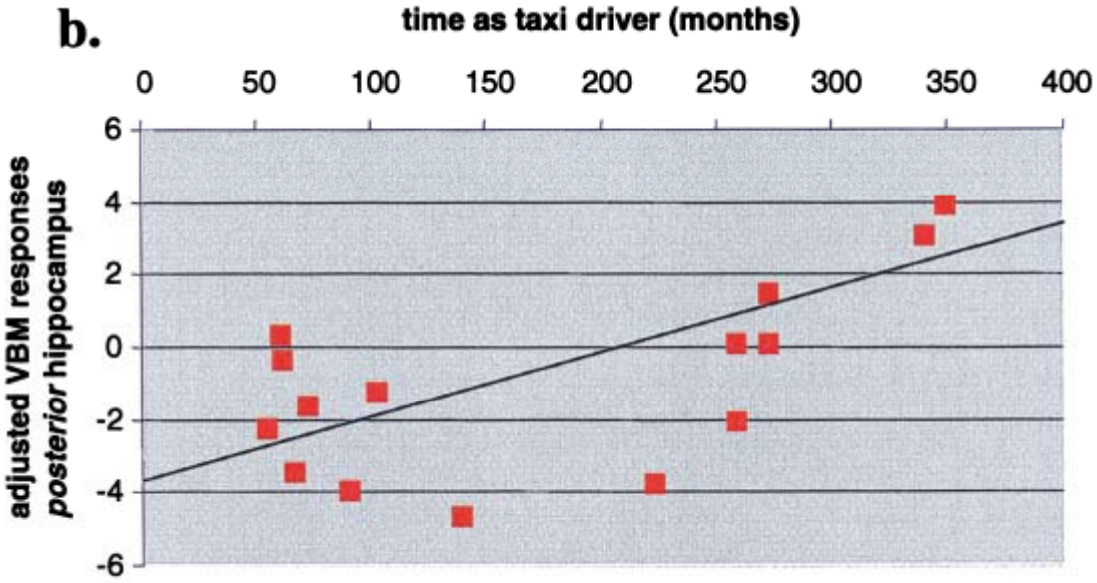

Scientists used to think human brains would not grow new neurons as adults.

But now we know we do grow new neurons as adults, and…

The more you use your brains,
the more new neurons you grow,
and the healthier you are.